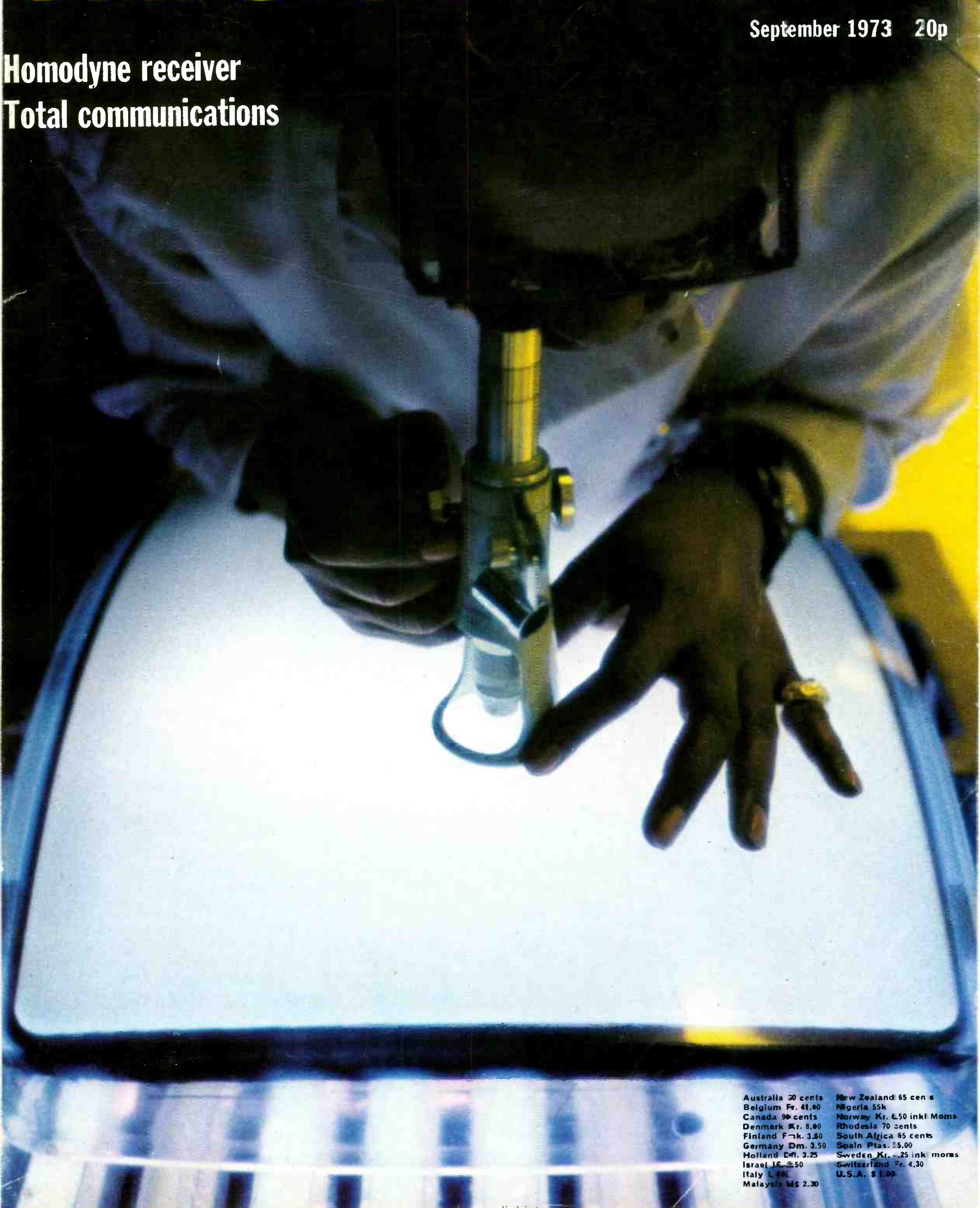
# Wireless World

September 1973 20p

Homodyne receiver

Total communications



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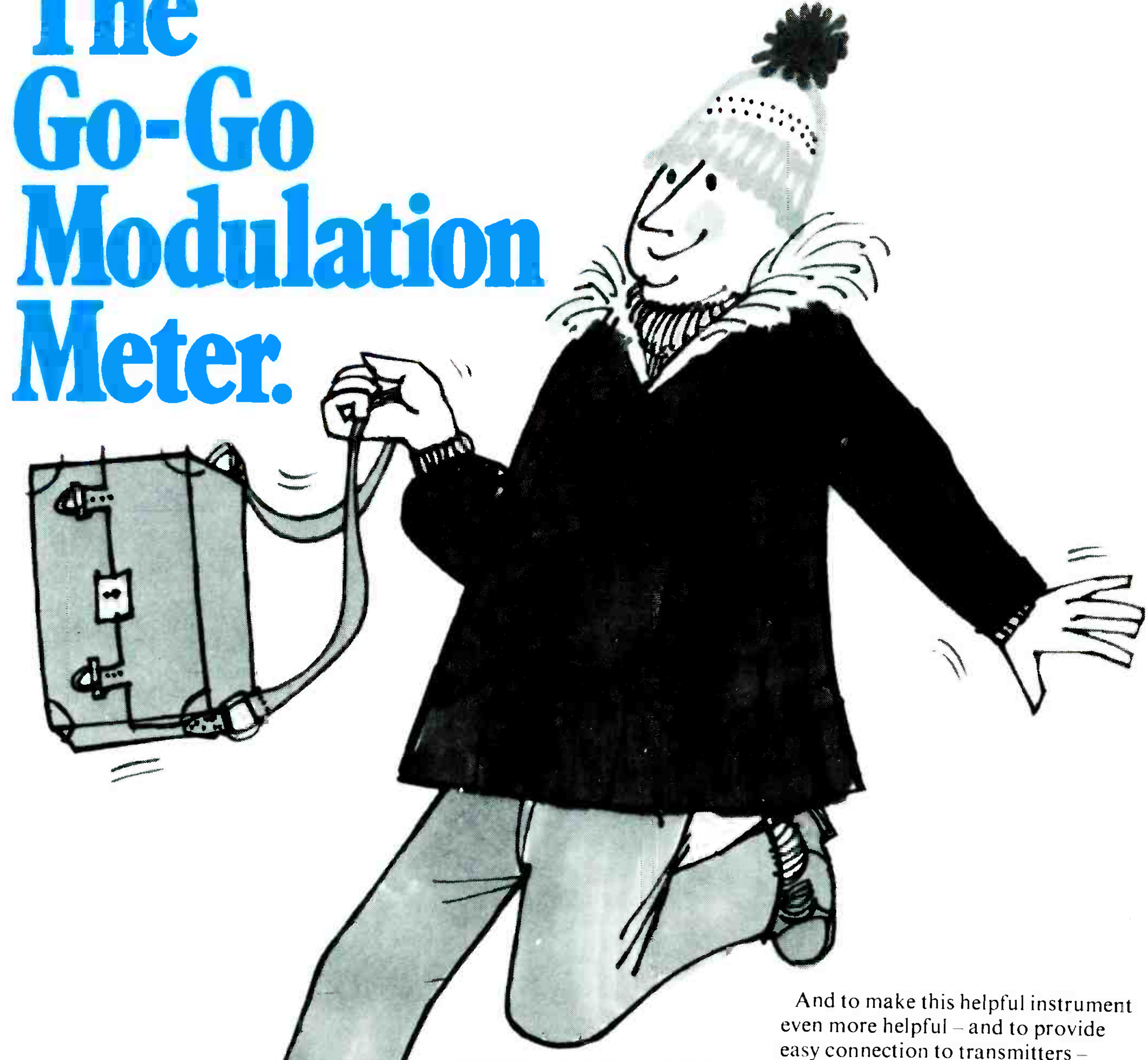
# The Go-Go Modulation Meter.



Meet the masterly modulation meter that goes wherever you go: M.I.'s f.m./a.m. TF 2303.

Portable, compact, light to carry in its special case with compartment for accessories, it operates both on mains and on re-chargeable batteries for time-saving, trouble-saving mobile radio testing in the field.

The TF 2303 measures f.m. deviation in three ranges from 1·5 kHz to 15 kHz at carrier frequencies up to 520 MHz, the expanded lower range being particularly useful for measuring narrow band performance. It has 'locked on' frequency control as a further advantage. And it is substantially protected against overload damage. All this . . . and splendid value too!

And to make this helpful instrument even more helpful – and to provide easy connection to transmitters – there's the most comprehensive range of accessories; a de-emphasis unit, a 12-watt termination, one-watt and twenty-watt 20dB attenuators, a 'signal sniffer', and an r.f. fuse.

No doubt about it: M.I.'s TF 2303 is just what you need where the action is – either at your bench or out and about here, there, and everywhere. So get going with it just as soon as you can!

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**Manchester Electronic Instruments Exhibition,**
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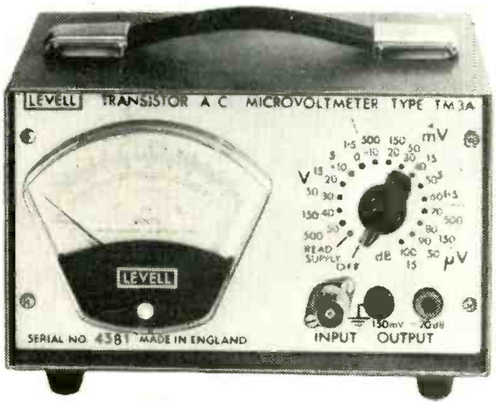
**NOTE: All prices subject to V.A.T.**

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have $3\frac{1}{4}$" scale meters, and case sizes 5" x 7" x 5". B types have 5" mirror scale meters and case sizes 7" x 10" x 6".




## A.C. MICROVOLTMETERS

**VOLTAGE & db RANGES**: 15µV, 50µV, 150µV ... 500V f.s.d. Acc. ± 1% ± 1% f.s.d. ± 1 µV at 1 kHz. − 100, − 90 ... + 50dB, scale − 20dB/+ 6dB rel. to 1mW/600Ω.
**RESPONSE**: ± 3dB from 1 Hz to 3MHz, ± 0·3dB from 4Hz to 1 MHz above 500 µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10 kHz or 100 kHz.
**INPUT IMPEDANCE**: Above 50mV : > 4·3MΩ < 20pf. On 50µV to 50mV : > 5MΩ < 50pf.
**AMPLIFIER OUTPUT**: 150mV at f.s.d.

**£49** type TM3A **£63** type TM3B

## D.C. MICROVOLTMETERS

**VOLTAGE RANGES**: 30µV, 100µV, 300µV ... 300V. Acc. ± 1%, ± 2% f.s.d., ± 1 µV. CZ scale.
**CURRENT RANGES**: 30 pA, 100 pA, 300 pA, 300 mA. Acc. ± 2%, ± 2% f.s.d., ± 2 pA. CZ scale.
**LOGARITHMIC RANGE**: ± 5µV at ± 10% f.s.d., ± 5 mV at ± 50% f.s.d., ± 500 mV at f.s.d.
**RECORDER OUTPUT**: ± 1V at f.s.d. into > 1kΩ

**£55** type TM10 (appearance similar to type TM9B)


## D.C. MULTIMETERS

**VOLTAGE RANGES**: 3µV, 10µV, 30µV ... 1kV. Acc. ± 1% ± 1% f.s.d. ± 0·1 µV. LZ & CZ scales.
**CURRENT RANGES**: 3pA, 10pA, 30pA ... 1mA (1A for TM9BP) Acc. ± 2% ± 1% f.s.d. ± 0·3pA. LZ & CZ scales.
**RESISTANCE RANGES**: 3 Ω, 10 Ω, 30 Ω ... 1kM Ω linear. Acc. ± 1%, ± 1% f.s.d. up to 100M Ω.
**RECORDER OUTPUT**: 1V at f.s.d. into > 1k Ω on LZ ranges.

**£75** type TM9A **£89** type TM9B **£93** type TM9BP


## BROADBAND VOLTMETERS

**H.F. VOLTAGE & dB RANGES**: 1mV, 3mV, 10mV ... 3V f.s.d. Acc. ± 4% ± 1% of f.s.d. at 30MHz. − 50dB, − 40dB, − 30dB to + 20dB. Scale − 10dB/+ 3dB rel. to 1mW/50 Ω. ± 0·7dB from 1MHz to 50MHz. ± 3dB from 300kHz to 400MHz.
**L.F. RANGES**: As TM3 except for the omission of 15µV and 150µV.
**AMPLIFIER OUTPUT**: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

**£85** type TM6A **£99** type TM6B

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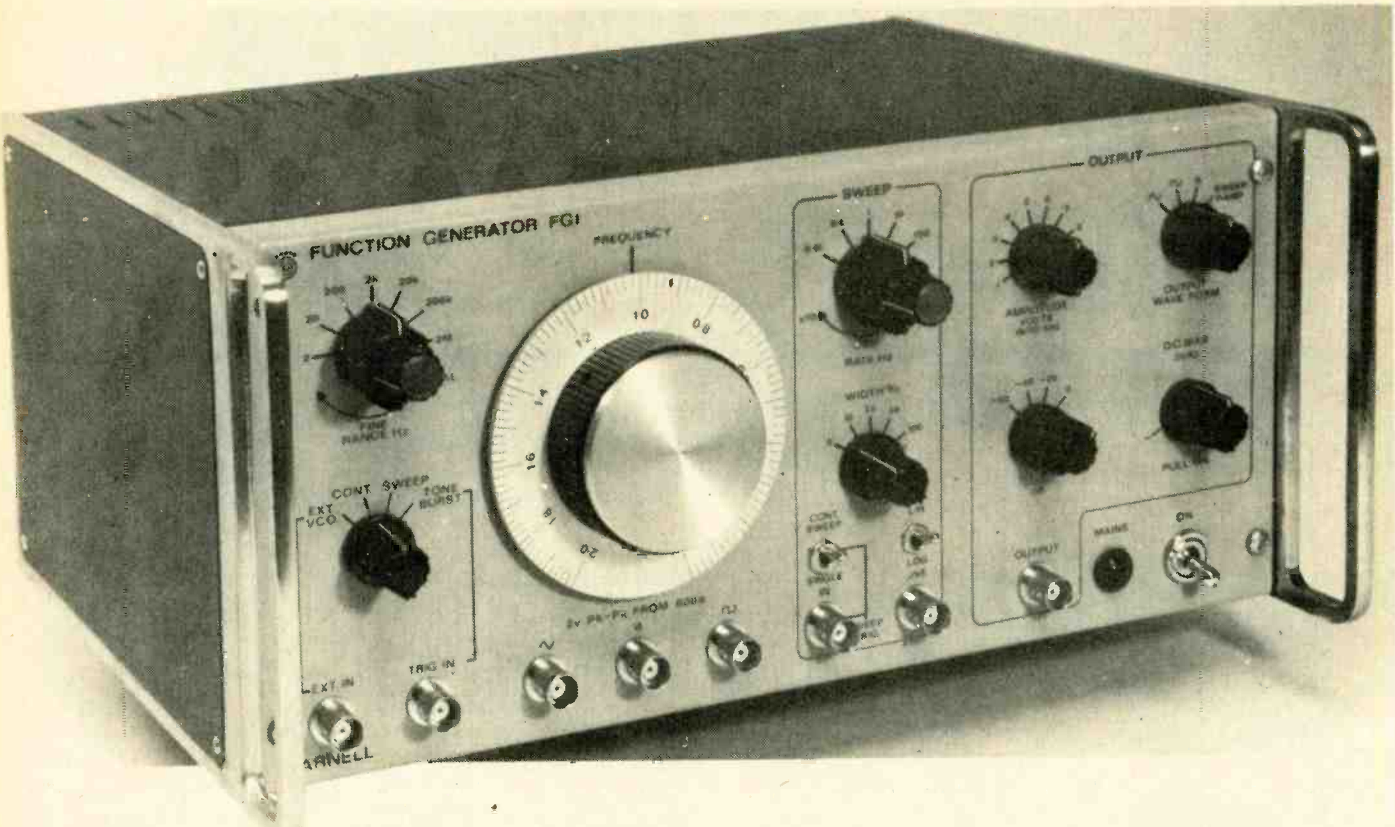


## *THE FG1 FUNCTION GENERATOR*

**WAVEFORMS AVAILABLE**
Sine, square, triangles and ramps. Continuous swept, triggered, gated bursts, frequency modulated, externally sync'd.

**AMPLITUDE**
Max. 20V pk–pk into open circuit (10V into 50 Ω) on selected waveform at main output. Adjustable from 1 mV.
Four basic waveforms available simultaneously from 600 Ω at fixed level of 2.5V pk–pk.

**ATTENUATOR**
4 positions, 60dB in 20dB steps. For best possible resolution and signal to noise ratio at low signal levels.

**FREQUENCY**
0.02Hz to 2MHz in seven decade ranges – sine, square and triangle. 1000:1 continuous coarse and fine adjustment on each range. 0.01 Hz to 1 kHz in five decade ranges – ramp. Dial accuracy ±3% of range max. 0.02 Hz to 200kHz.

**OFFSET**
±5V d.c. bias will offset waveform above or below zero. Push-pull adjustable control.

**EXT. VCO**
0 to +10V gives 1000:1 frequency upshift from min. dial setting.
0 to –10V gives 1000:1 frequency down shift from max. dial setting, within any selected range.
Voltage may be a.c. or d.c.
Frequency modulation of the output about a centre frequency is possible.

**SWEEP**
Range: 1000 to 1. Mode: Lin or log. Times 1 mS to 1000S.
Width: 5 position switch gives stepped reductions as a percentage of max.

**SYNC**
Sync. pulse output may be used to trigger an oscilloscope, X-Y plotter etc. Or the output frequency of the FG1 may be locked to a periodic reference signal for tests requiring coherent signals.

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# EHPL-

## it takes over where MTBF leaves off

While others talk of MTBF, we introduce a new concept—EHPL, Estimated Half-Power Life. Our 400W and 1kW all-solid-state broadband HF linear amplifiers have over five years of it, counted in operational hours. Which, with a remarkably low Mean Time To Repair, means 99.9% up-time.

The multiple p.a. modules of these compact units, arranged in parallel for maximum reliability, ensure that even in the unlikely event of several component failures occurring together, the amplifiers go on working—long after others have stopped.

Moreover, thanks to Redifon's unique Transmit Level Control, they always deliver to any antenna—even to a badly damaged one—the maximum power that is safe, whatever the mismatch.

All of which means that the pair of transmitters in the picture represent the finest and most reliable in the world for civil and military applications, whether in fixed, mobile or containerised stations. And they are in production and service, right now.


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1kW

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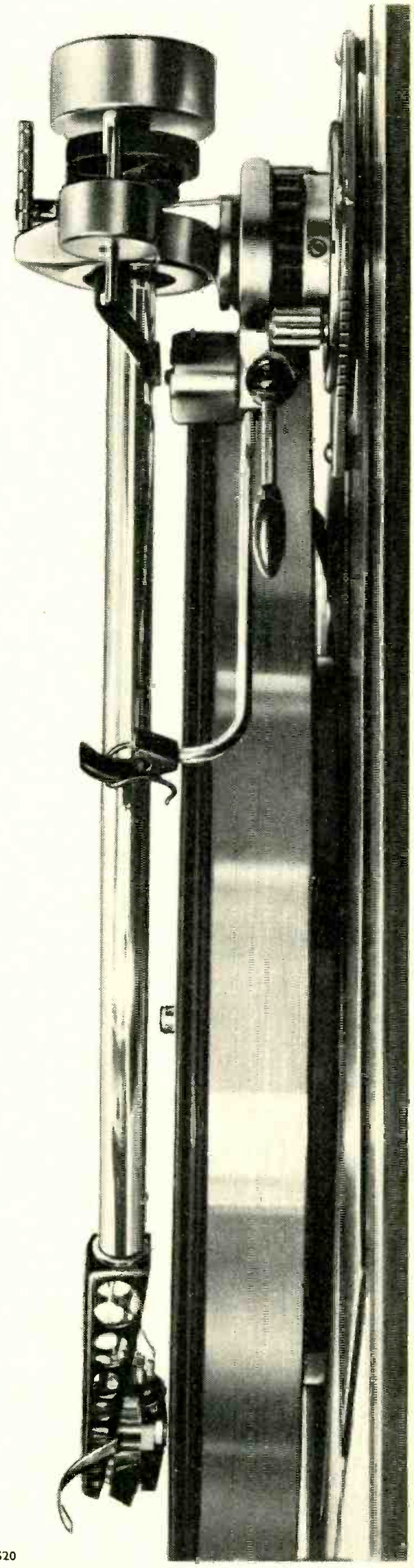

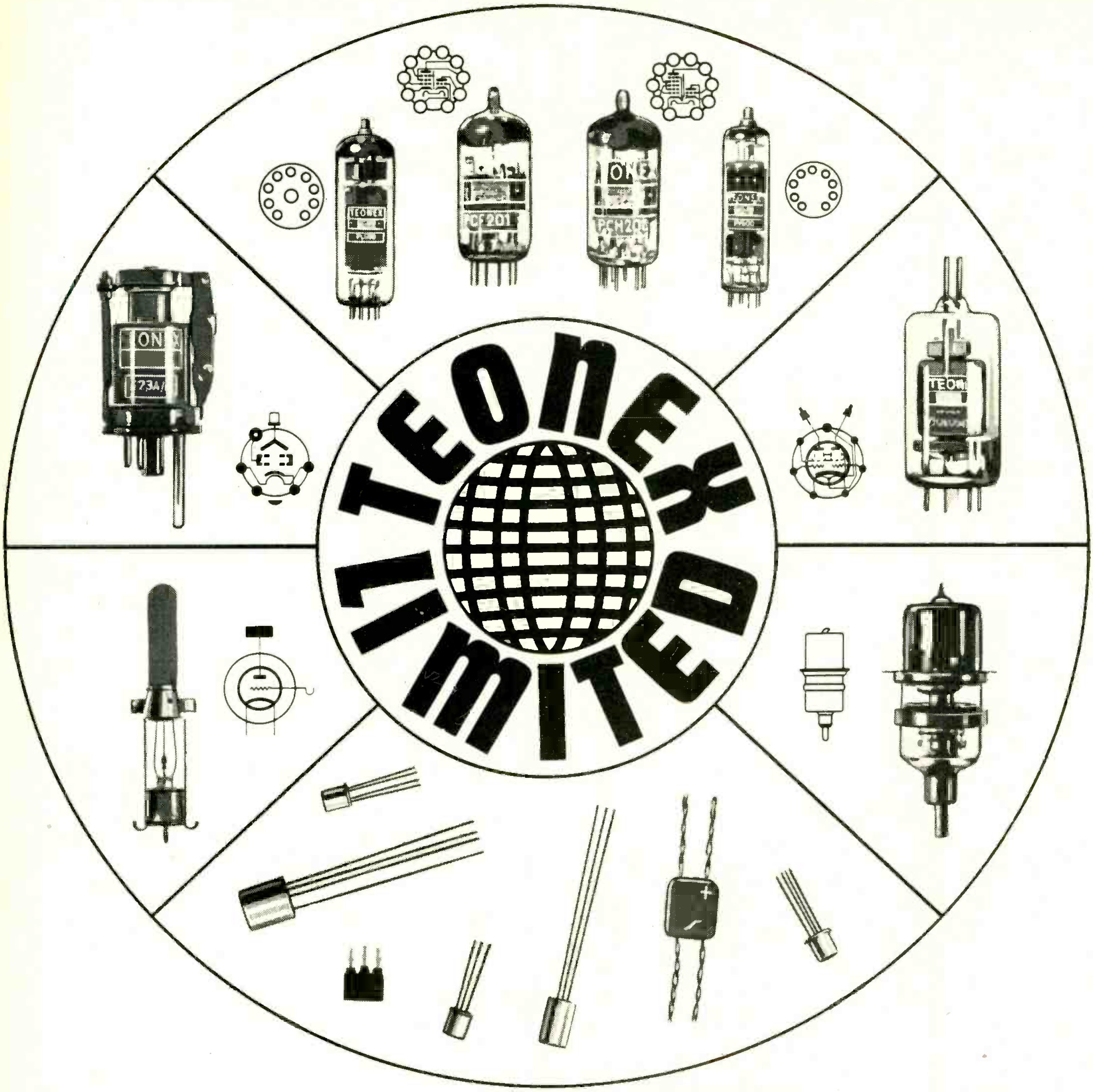


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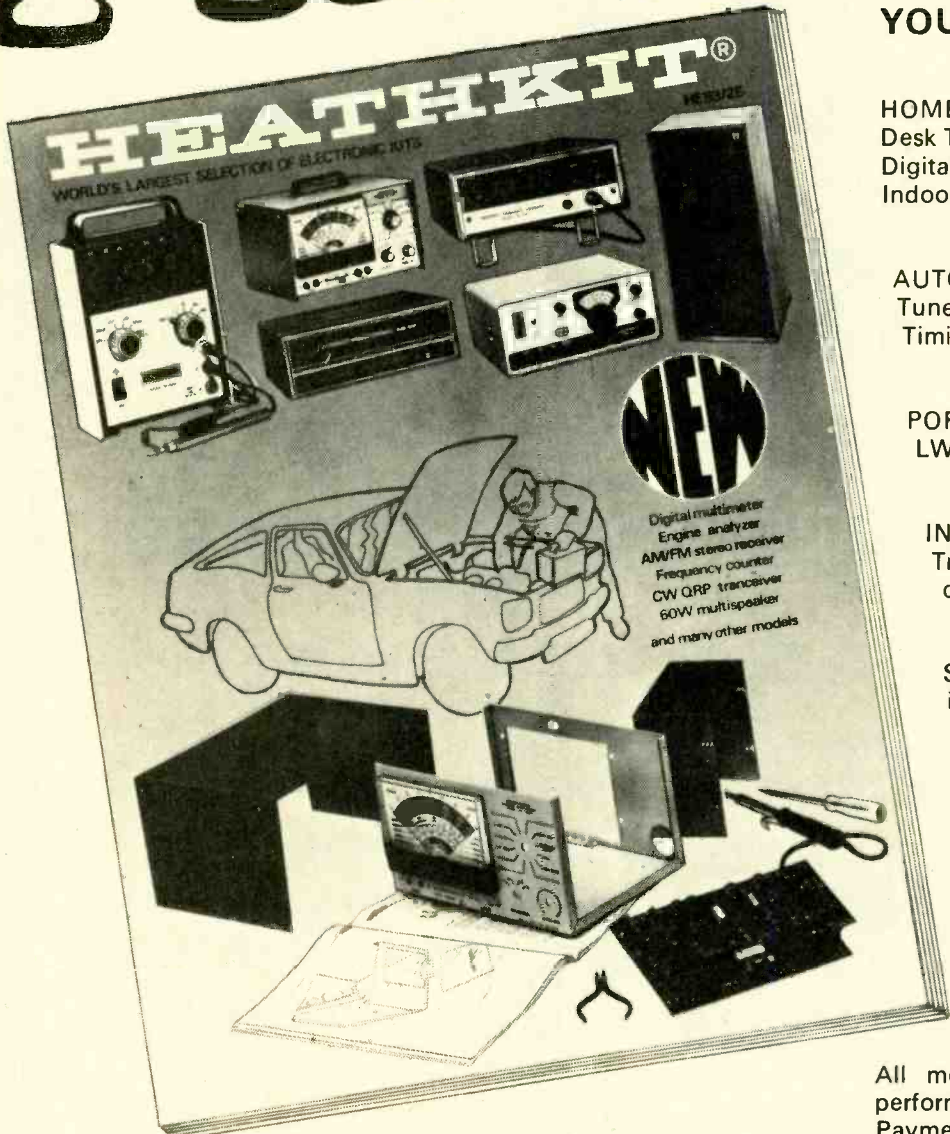


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# Modular Filtering

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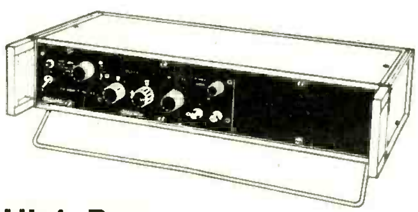
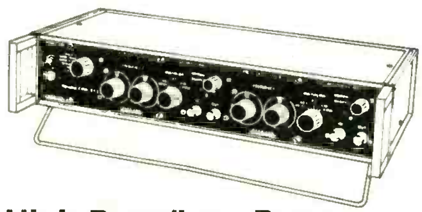
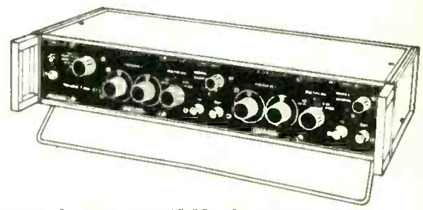


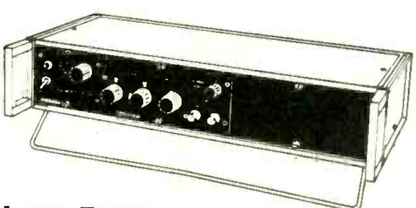
**High Pass**



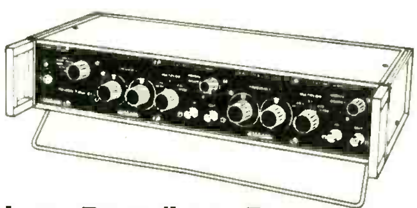
**High Pass/Low Pass**



**High Pass/High Pass**



**Low Pass**



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Barr & Stroud's new EF3 Electronic Filter System means no more compromises when you buy variable filters. Now you can get the filter you need today, and additional plug-in units tomorrow. Today — the basic main frame and your choice of two modules to operate in low-pass, high-pass, band-pass, band-stop, band-separate, band-combine or cascade modes. Tomorrow — other interchangeable modules to meet your newest requirements. The first two modules, already available, provide filtering with variable cut-offs between 0.01 Hz and 10.0kHz, stop-band attenuation of 48dB/oct. (96dB/oct. in cascade), and pass-band response from dc to 500kHz. Get full details of EF3, the big breakthrough in electronic filtering by using the reply card.

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Each Circard is 8″ x 5″ and shows a specific circuit, a description of the circuit operation; component values and ranges; circuit limitations; circuit modifications; tested circuits; performance data and graphs.

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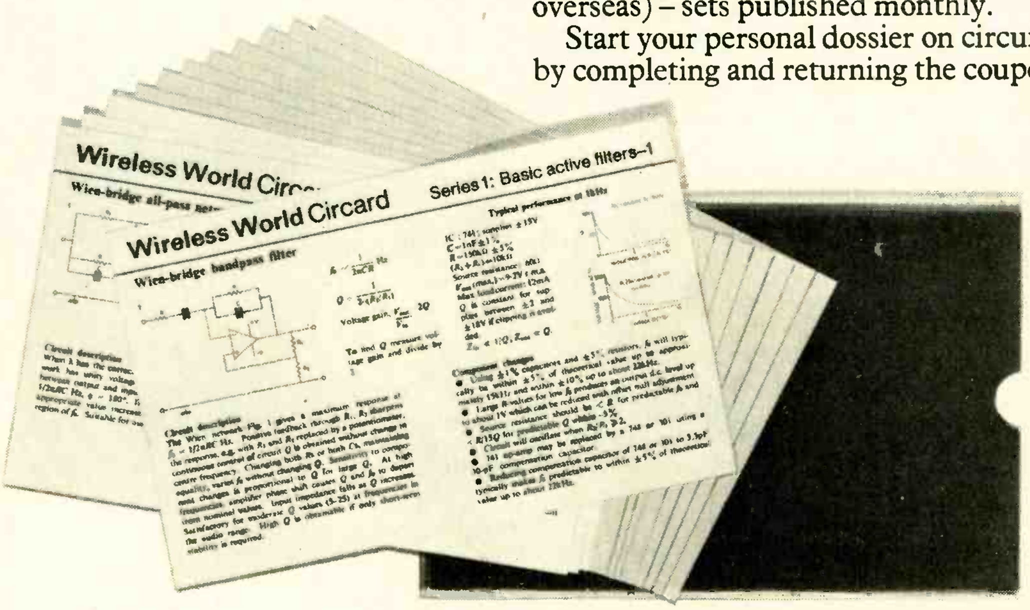


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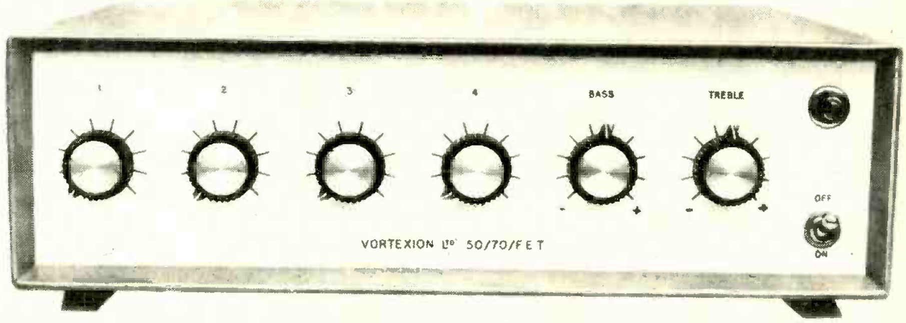
# Vortexion

## 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4-WAY MIXER USING F.E.T.s.




This is a high fidelity amplifier (0.3% intermodulation distortion) using the circuit of our 100% reliable 100 Watt Amplifier with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer Amplifier, again fully protected against overload and completely free from radio breakthrough.

The mixer is arranged for 2–30/60 Ω balanced line microphones, 1-HiZ gram input and 1-auxiliary input followed by bass and treble controls. 100 volt balanced line output or 5/15 Ω and 100 volt line.

**50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 5-WAY MIXER USING F.E.T.s.** This is similar to the 4-way version but with 5 inputs and bass cut controls on each of the three low impedance balanced line microphone stages, and a high impedance (10 meg) gram stage with bass and treble controls plus the usual line or tape input. All the input stages are protected against overload by back to back low self capacity diodes and all use F.E.T's for low noise, low intermodulation distortion and freedom from radio breakthrough. A voltage stabilised supply is used for the pre-amplifiers making it independent of mains supply fluctuations and other stabilised supply for the driver stages is arranged to cut off when the output is overloaded or over temperature. The output is 75% efficient and 100V balanced line or 8/16 Ω output are selected by means of a rear panel switch which has a locking plate indicating the output impedance selected. The mixer section has an additional emitter follower output for driving a slave amplifier, phones or tape recorder, output .3 V out on 600 ohms upwards.

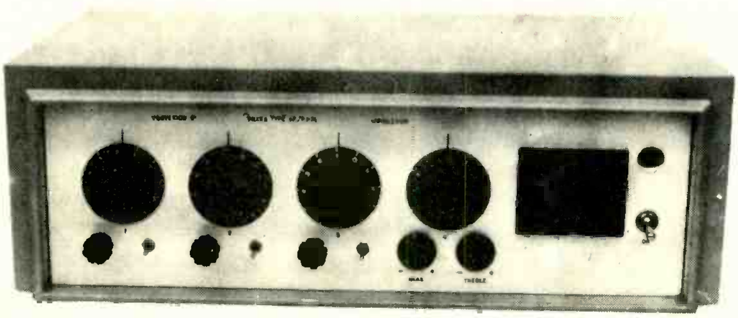
**100 WATT ALL SILICON AMPLIFIER.** A high quality amplifier with 8 ohms–15 ohms or 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4 V on 100K ohms.

**THE 100 WATT MIXER AMPLIFIER** with specification as above is here combined with a 4 channel F.E.T. mixer, 2–30/60 Ω balanced microphone inputs, 1-HiZ gram input and 1-auxiliary input with tone controls and mounted in a standard robust stove enamelled steel case. A stabilised voltage supply feeds the tone controls and pre amps, compensating for a mains voltage drop of over 25% and the output transistor biasing compensates for a wide range of voltage and temperature. Also available in rack panel form.

**CP50 AMPLIFIER.** An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected inputs, and overload and short circuit protected outputs for 8 ohms–15 ohms and 100 volt line. Bass and treble controls fitted.
Models available with 1 gram and 2 low mic. inputs, 1 gram and 3 low mic. inputs or 4 low mic. inputs.

**200 WATT AMPLIFIER.** Can deliver its full audio power at any frequency in the range of 30 c/s–20 Kc/s ± 1 dB. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1 mW 600 ohms. Output 100-120 V or 200-240 V. Additional matching transformers for other impedances are available.

## F.E.T. MIXERS and PPMs.



Since we have been supplying professional mixers for 25 years we have delayed the introduction of solid state units until they were at least as good as their valve counterparts. (Which will continue where required.)

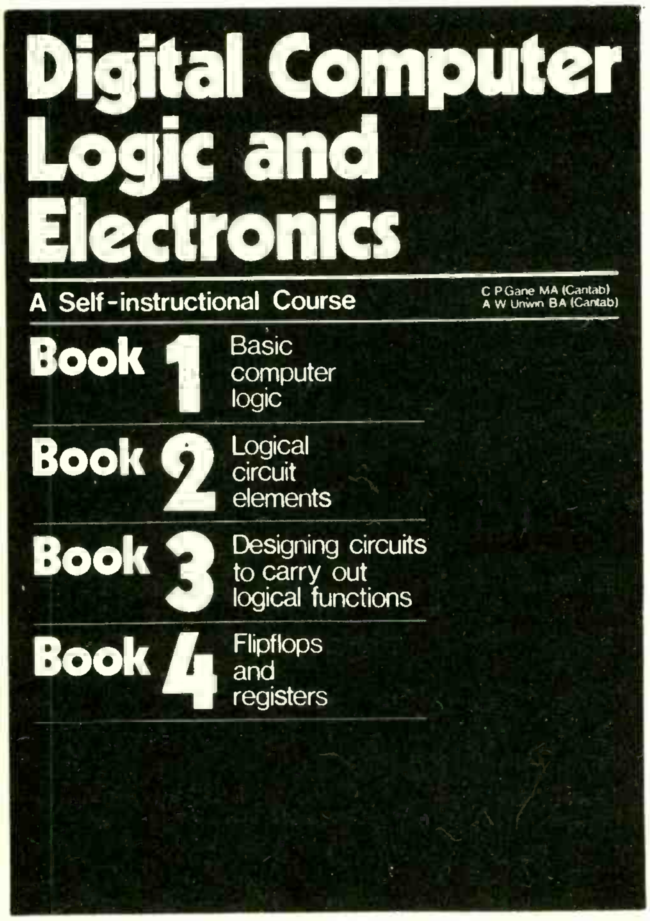
The various sections of the FET mixers and BBC type PPM's have been performing successfully for several years in other equipments with complete reliability. The PPM also uses an FET in its time constant circuit so that polyester capacitors can be used. The response from the 600 Ω output (25 Ω source impedance) is level 20 Hz to over 30 kHz with very low intermodulation distortion to zero level + 12dB. The input signal voltage range is over twice that of the valve unit and the noise at least halved.

**VORTEXION LIMITED,** **257-263 The Broadway, Wimbledon, S.W.19**

**Telephone: 01-542 2814 and 01-542 6242/3/4** **Telegrams: "Vortexion, London S.W.19"**

WW—016 FOR FURTHER DETAILS

# Join the Digital Revolution




## Teach yourself the latest techniques of digital electronics

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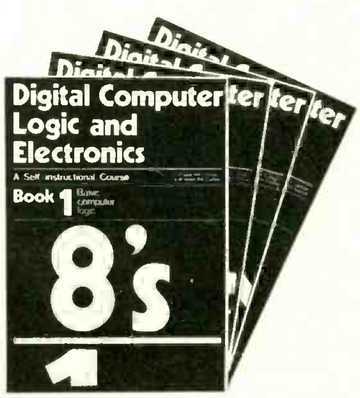


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Each of these bridges has ten decade ranges and can be used to measure any type of component or complex impedance. Transformer ratio-arms are used to cover a very wide range of measurement using a minimum number of standards which are set digitally. The three terminal facility provided by this type of bridge enables small values of capacitance or high values of resistance to be measured at the end of long lengths of cable. Components can also be effectively isolated electrically from a complex network allowing individual measurements to be made without disconnection from the circuit being necessary.

## The world's most universal audio bridges

# Wayne Kerr's B224 and B642



**The B224 is a manually operated bridge,** the resistive and reactive terms being independently set to a null indicated on the meter. A rechargeable battery is fitted in order to make the instrument portable.

**The B642 balances itself automatically.** The meters read real and quadrature terms and highly stable analogue outputs are provided which are directly proportional to capacitance and conductance above 10Ω impedance and also to inductance and resistance below 10Ω. One or two decades can be set to provide the first significant figures of the measurement, thereby increasing the meter sensitivity by 10 or 100 times. If a chart recorder is connected to the output of either term, drifts in component values to at least four significant figures can be observed.

### SPECIFICATION

| | B224 (Manual balance) | | B642 (Autobalance) | |
|---|---|---|---|---|
| Frequency | 1592Hz (internal)<br>200Hz – 50kHz (external) | | 1592Hz (internal)<br>200Hz – 20kHz* (external) | |
| Ranges for specified accuracy | | | | |
| | 0.1% | 0.3% | 0.1% | 0.3% |
| C | 100fF – 10µF | 10µF – 10mF | 1pF – . 10µF | 10µF – 10mF |
| G | 1n℧ – 100m℧ | 100m℧ – 1k℧ | 10n℧ – 100m℧ | 100m℧ – 100℧ |
| L | 1mH – 10kH | 100nH – 1mH | 1mH – 10kH | 1µH – 1mH |
| R | 10Ω – 1GΩ | 1mΩ – 10Ω | 10Ω – 100MΩ | 10mΩ – 10Ω |

NOTE: 0.1% accuracy relates to parallel component measurements above 10Ω impedance. 0.3% accuracy relates to series component measurements below 10Ω impedance.

**Manual operation only.*

For more information, either call Bognor (02433) 4501 or write to the address below:

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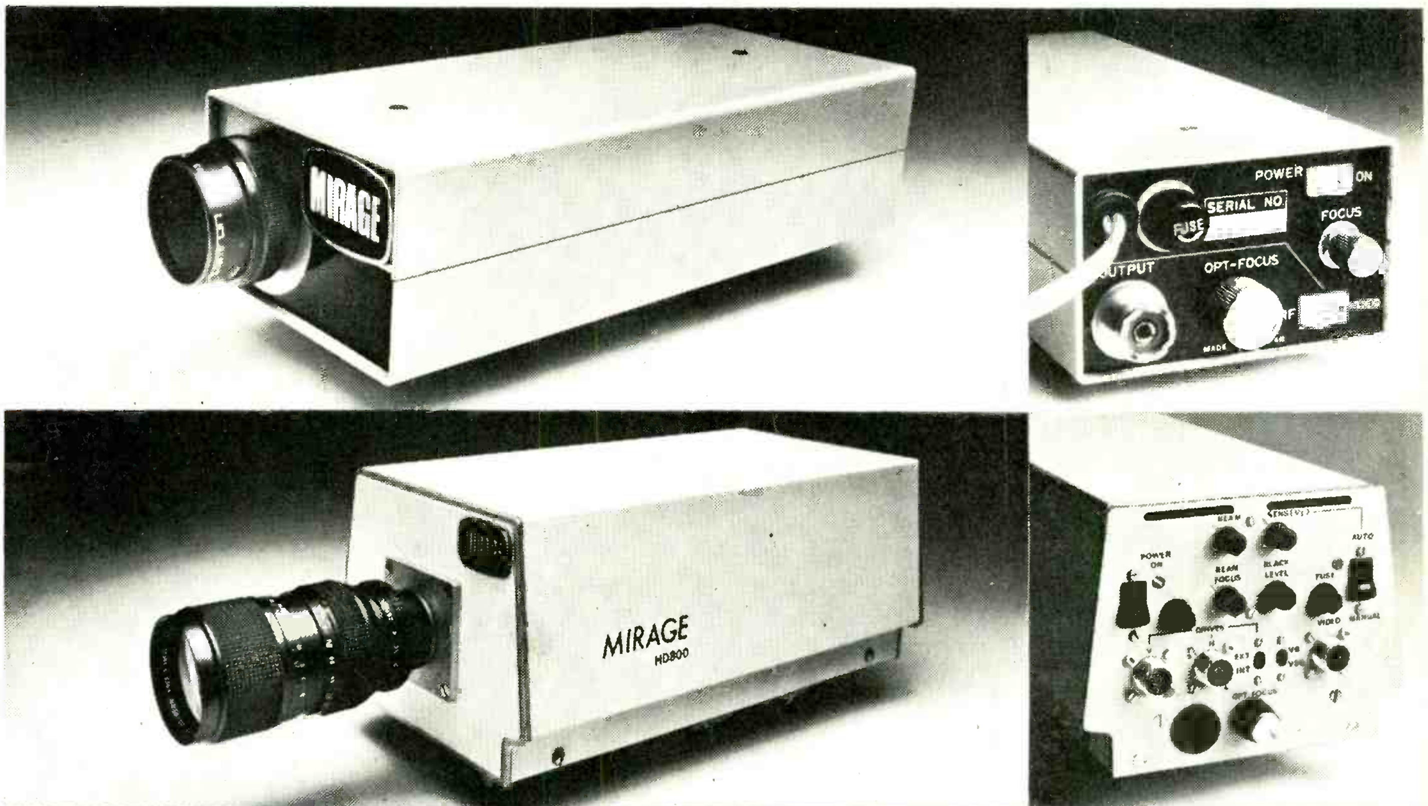
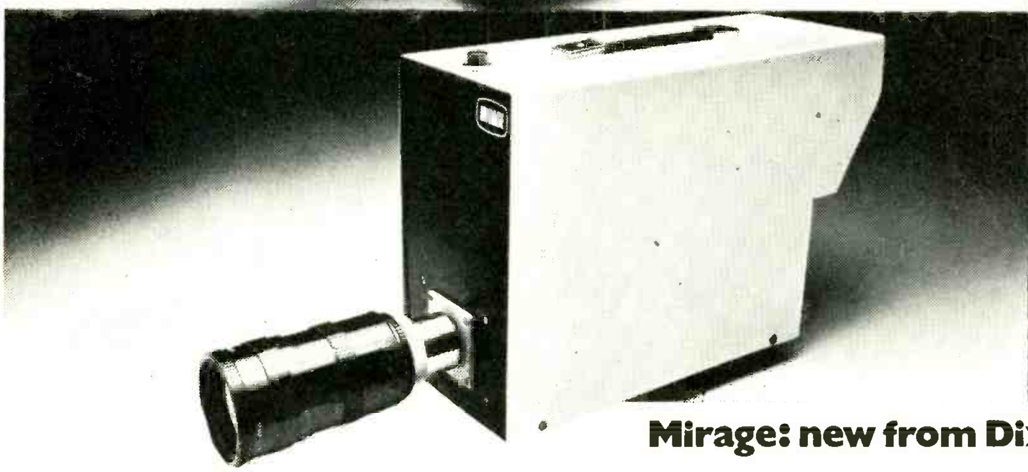
Durban Road, Bognor Regis, Sussex PO22 9RL

*A member of the Wilmot Breeden group.*

# Dixons Technical have something in black and white to make CCTV importers green with envy.



## Mirage: new from Dixons Technical.

Dixons Technical have the largest range of CCTV equipment in the country. And now they've added Mirage: their very own CCTV system.

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*Plumbicon is the registered trade mark of Mullard.

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# Westinghouse TV colour tubes guarantee purity in both colour and black & white

Today's Westinghouse Electric colour tubes, in addition to offering recognised excellence of colour definition, have white field purity...vitally important to reception of black and white transmission.

**Two 67 cm diagonal versions**
These improved Westinghouse tubes are made available in two configurations – the standard 90° and the 10 cm shorter profile wide-neck 110° version... permitting their compatibility to the needs of the larger portion of European TV set manufacturers.

**Expanded European facilities**
Pacing the growing demand in Europe for Westinghouse tubes, we have made a permanent commitment to fully support our customer. ■ With trained technical sales personnel in major European cities. ■ With warehousing and testing facilities in Kassel, W. Germany and Le Mans, France. ■ With a sustaining European oriented R&D programme.

**Customer oriented**
In these ways–compatible product availability–outstanding development facilities–local technical assistance...Westinghouse Electric respond to dynamic customer requirements – here in Europe and throughout the world.

The 110° Ⓦ A67-140X TV colour tube is 10 cm shorter in profile than the 90° Ⓦ A67-120X ...both offer superb colour definition as well as white field purity for black & white.

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Windsor Berks. Phone Windsor 63392. Telex 847069.

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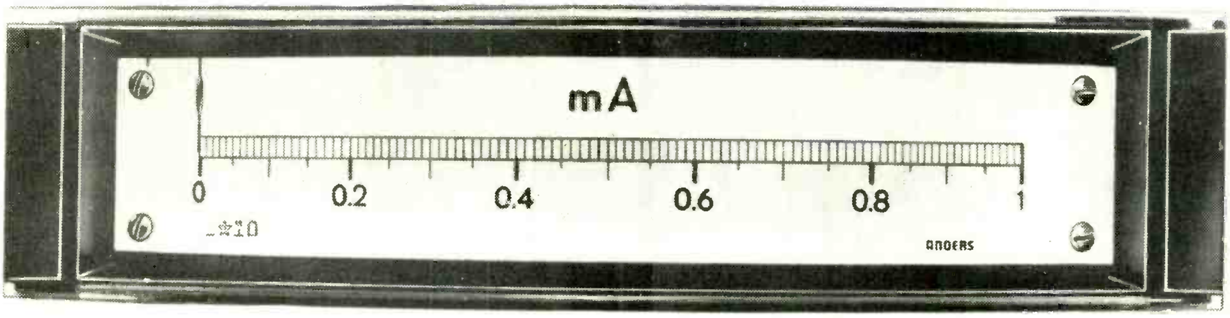
Westinghouse Electric

# ANDERS MEANS METERS...




*Actual size illustration*

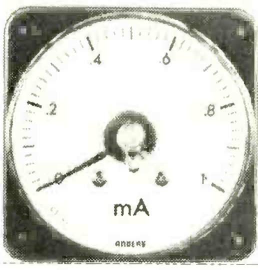
*Scale length 4·3″*

## PROFILE 350 EDGEWISE METER

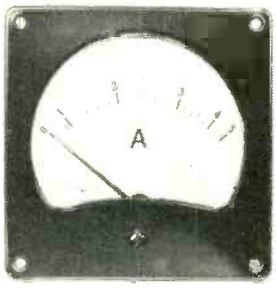
- Long scale while retaining small overall size
- Process control and electronic applications
- Easily stackable
- Horizontal/vertical use
- 60μA upward, AC/DC
- Self-shielding rugged movement

Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

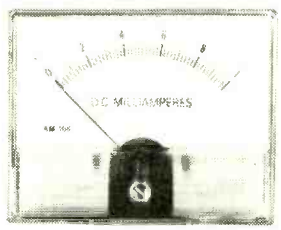
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



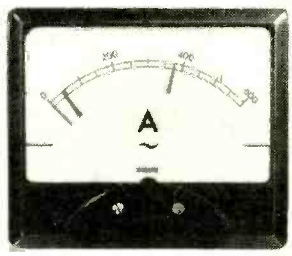

Oxford Long Scale 240°. 2 models, 5·5″, 8″ scales. DC moving coil and AC moving coil rectified.




Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.

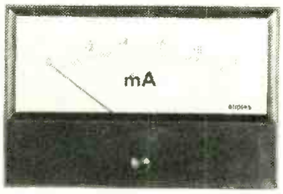


Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.

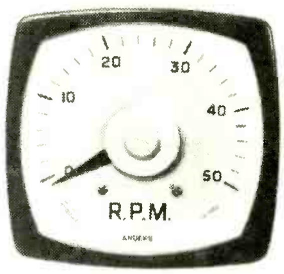



Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.

Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2″ and 2″. Available in sensitivities from 50 microamps Moving Coil.




Regal Range 100° flattened arc. 2 models 2.5″ and 3.2″ scales. Taut band. DC moving coil and AC moving coil rectified.




Stafford Long Scale 240 6 models, 3·5″—11·5″ scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.


Lancaster Long Scale 240 . 2 models, 4″, 5·5″ scales. DC moving coil and AC moving coil rectified.

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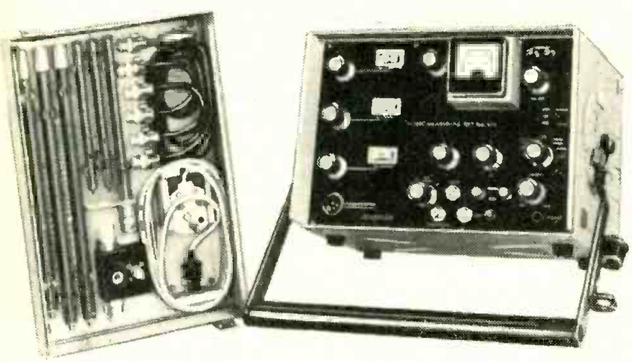

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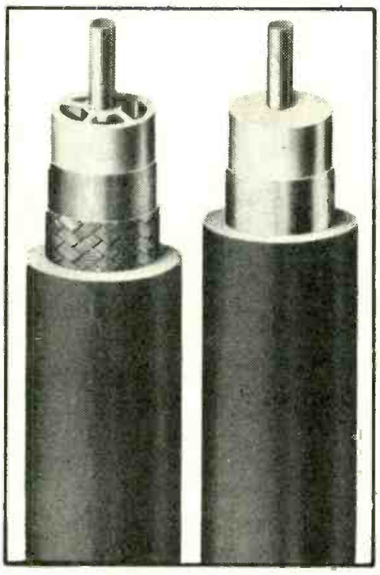

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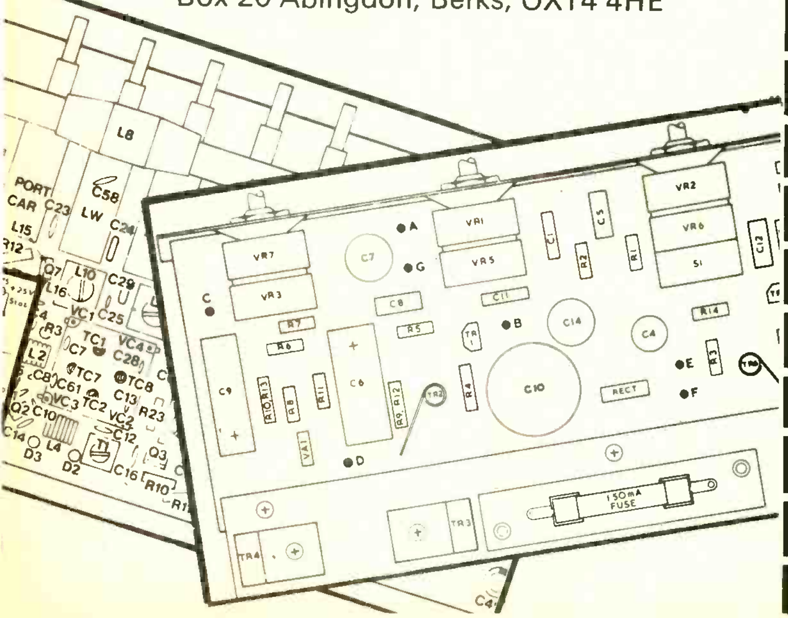

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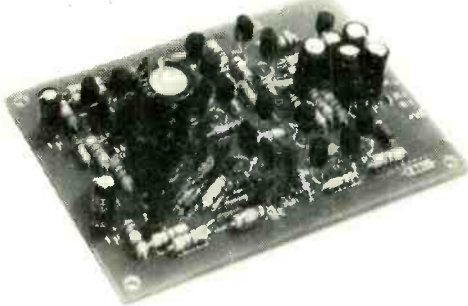

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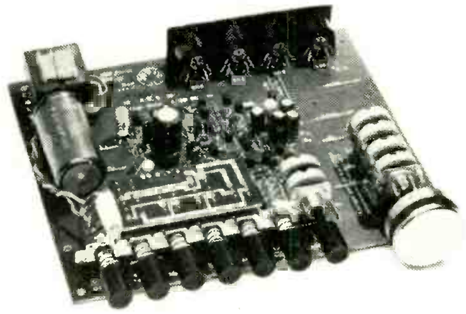

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WW93

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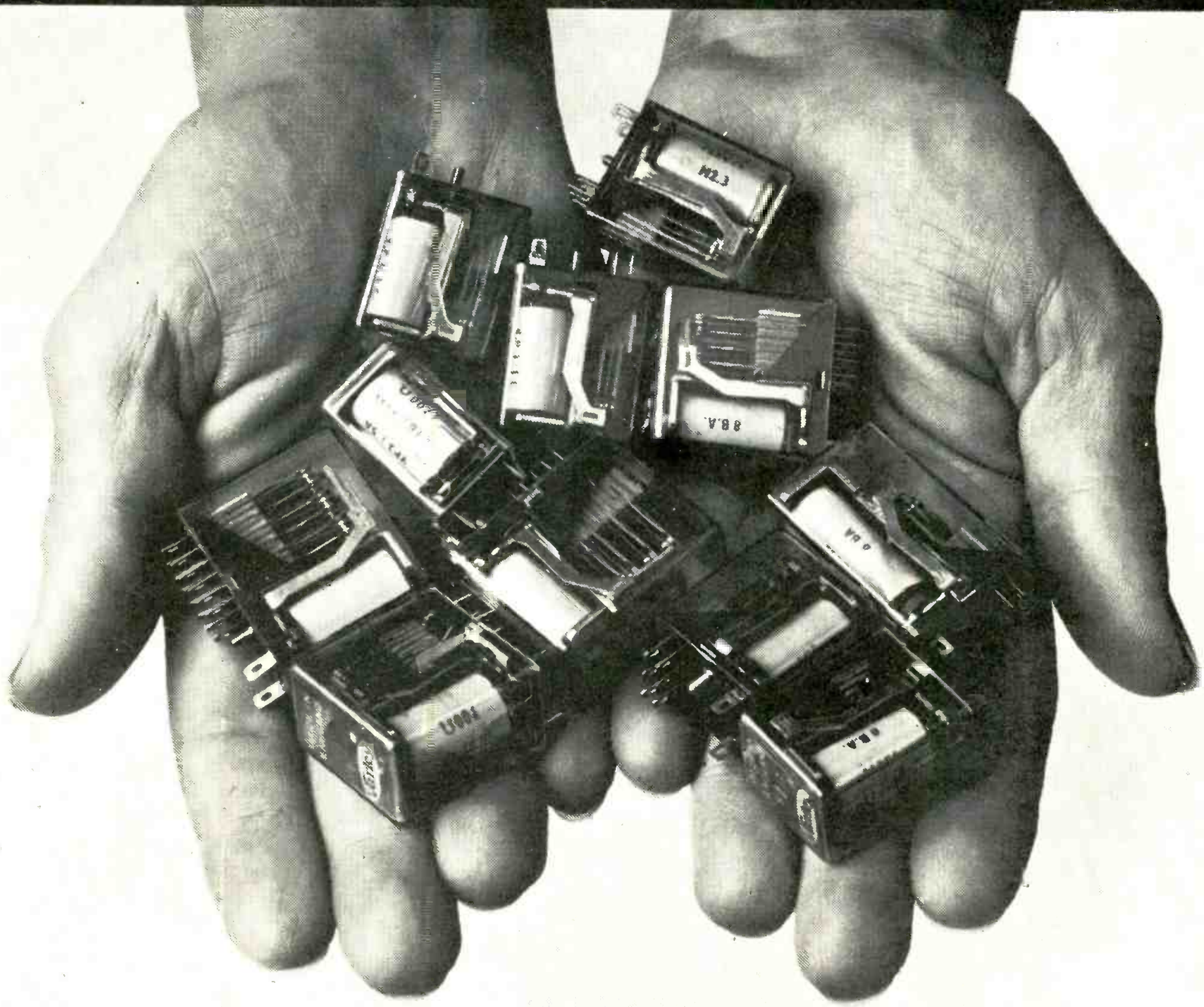

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____________ WW 9–73

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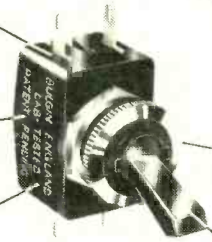


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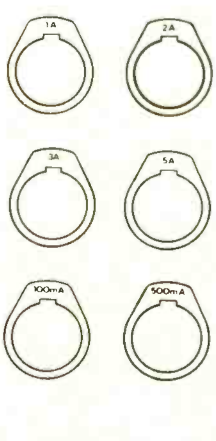


INTRODUCING a new design fuseholder F.396, which conforms to the safety standards of IEC 257, shown here fitted with our new 'rating indicator' P.No.11233/Rating. This simple attachment avoids the possibility of errors in fuse replacements, thus preventing damage to expensive electronic equipment due to incorrect fuse being used. The amperage of the fuse is clearly visible, being printed in black on a silver-matt finished aluminium background.

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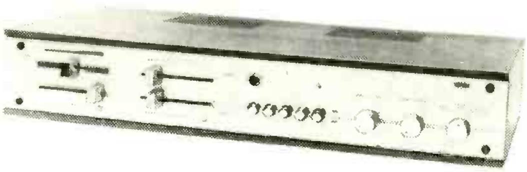

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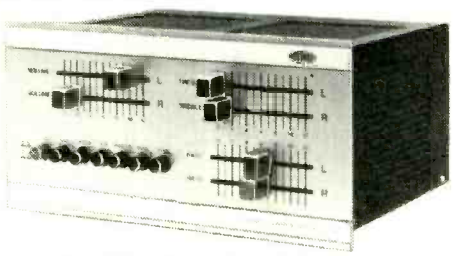

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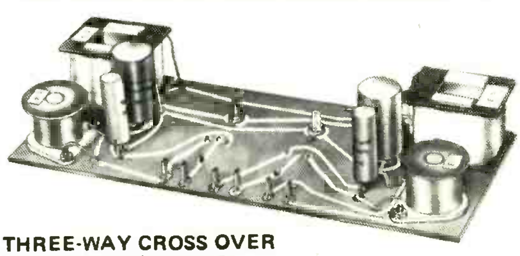

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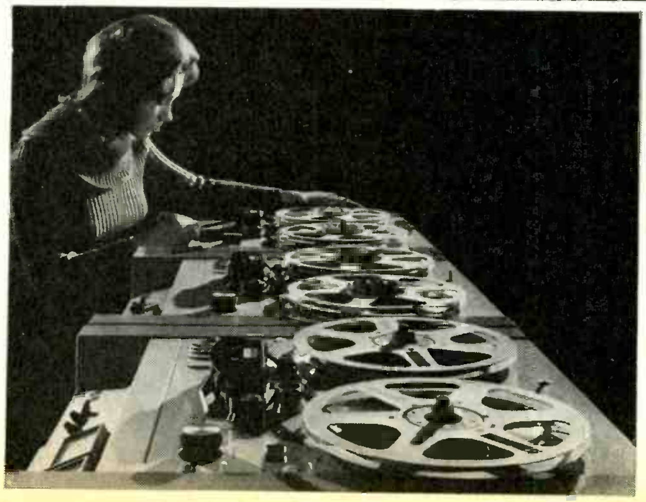

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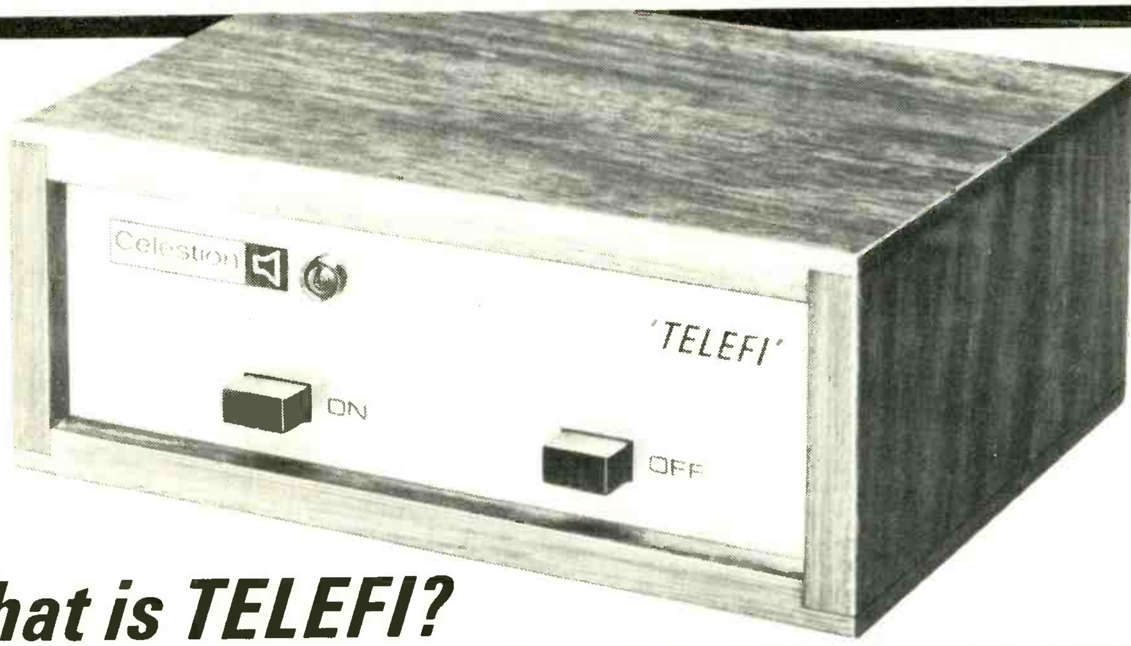


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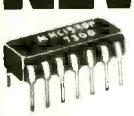
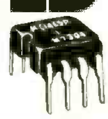

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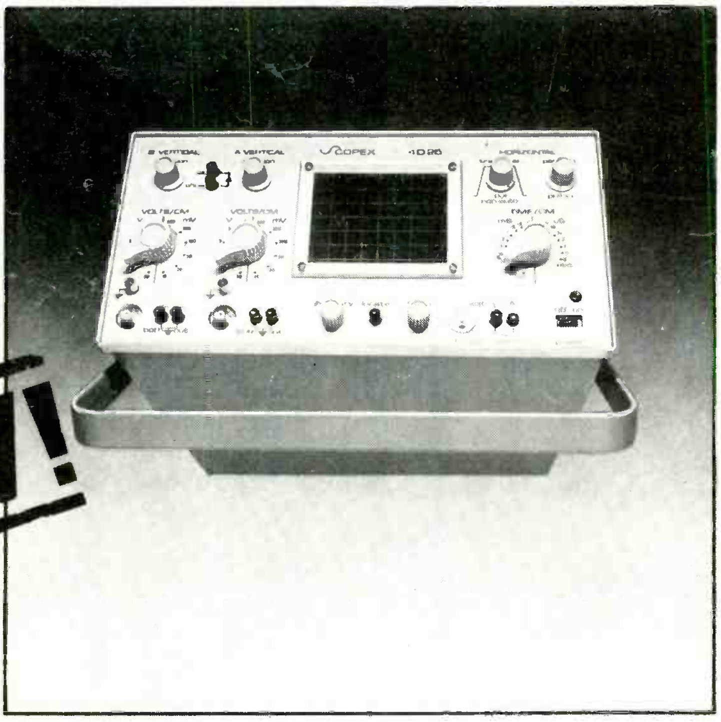

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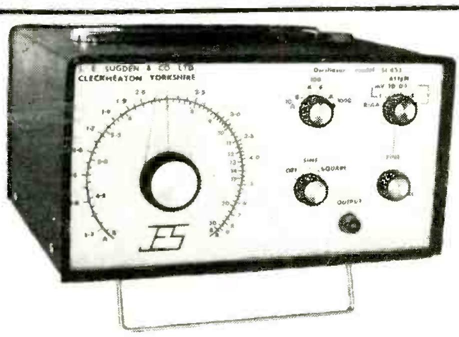

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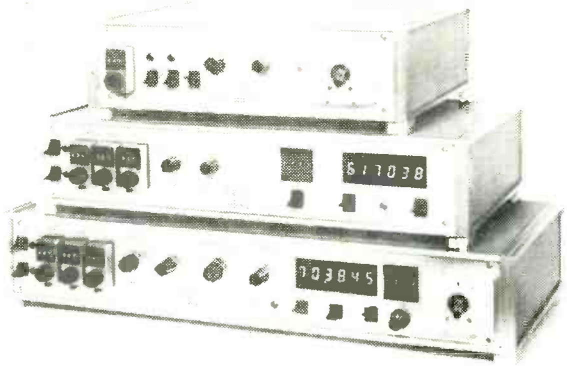

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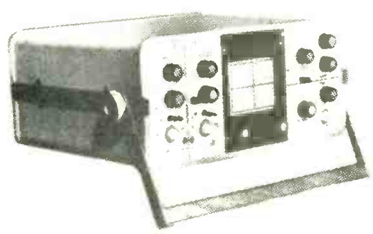

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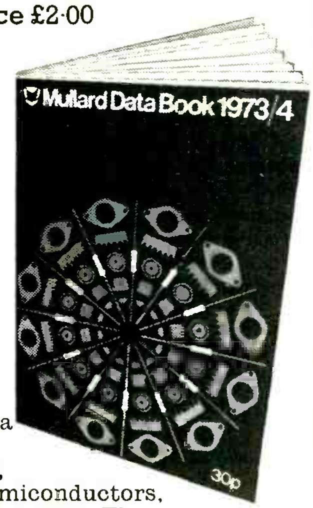


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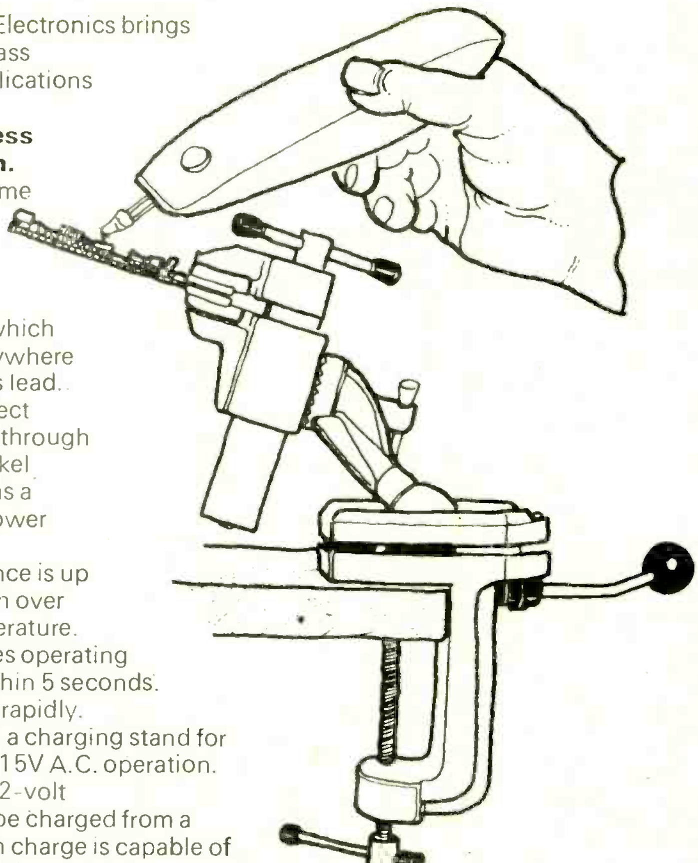

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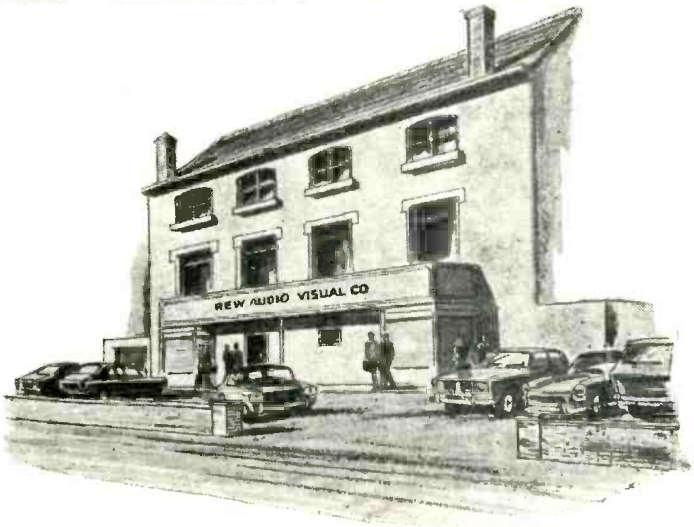


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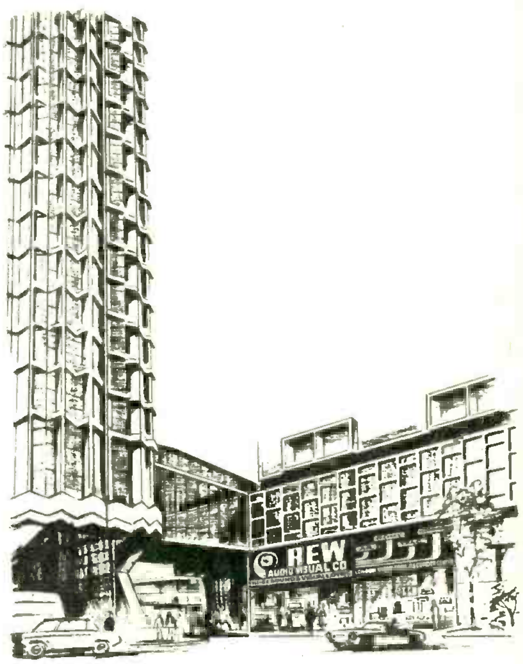


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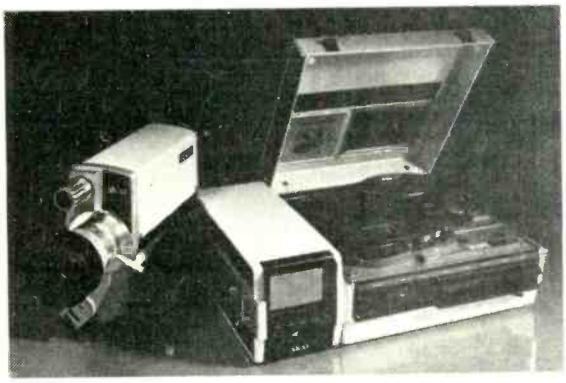

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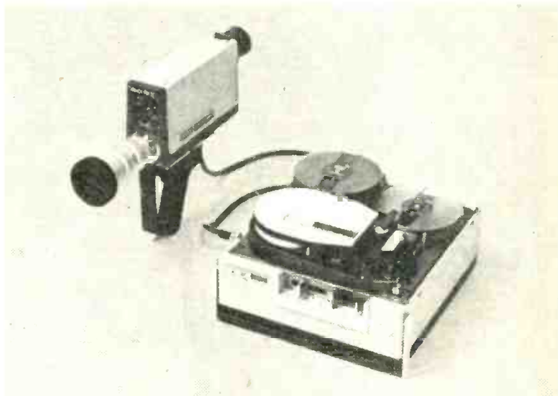

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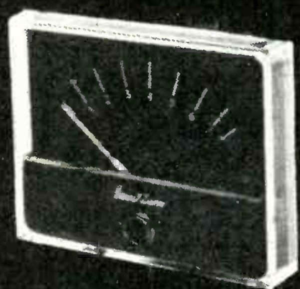

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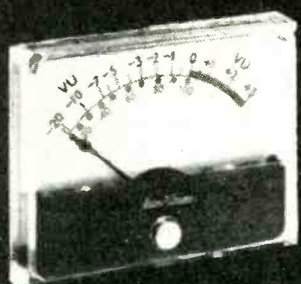



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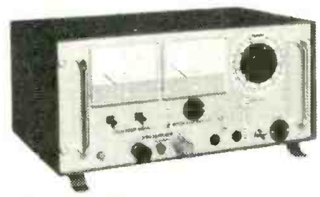

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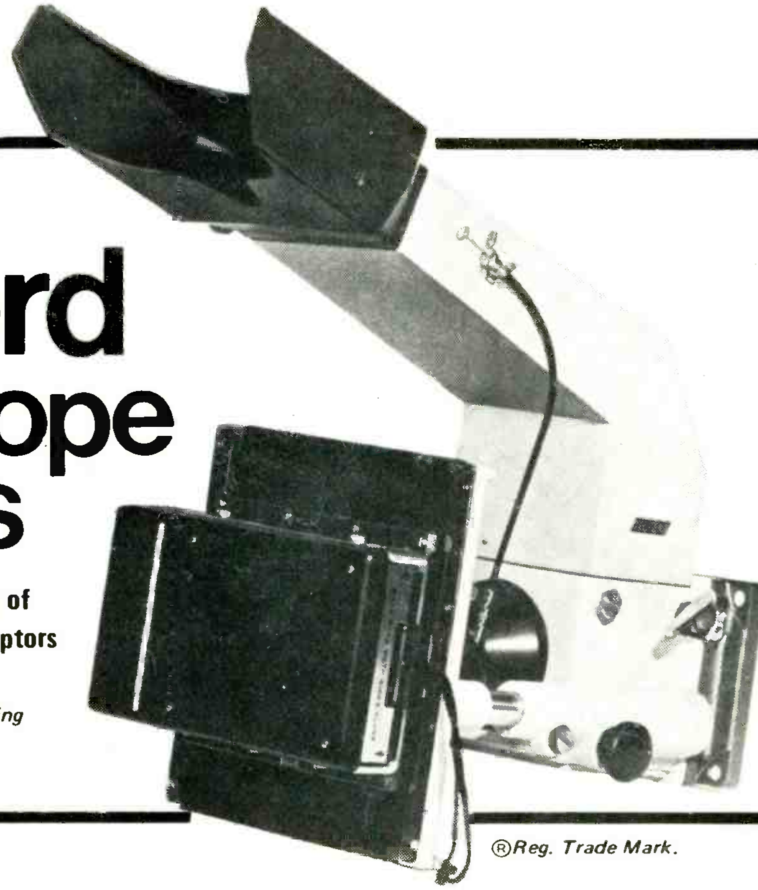

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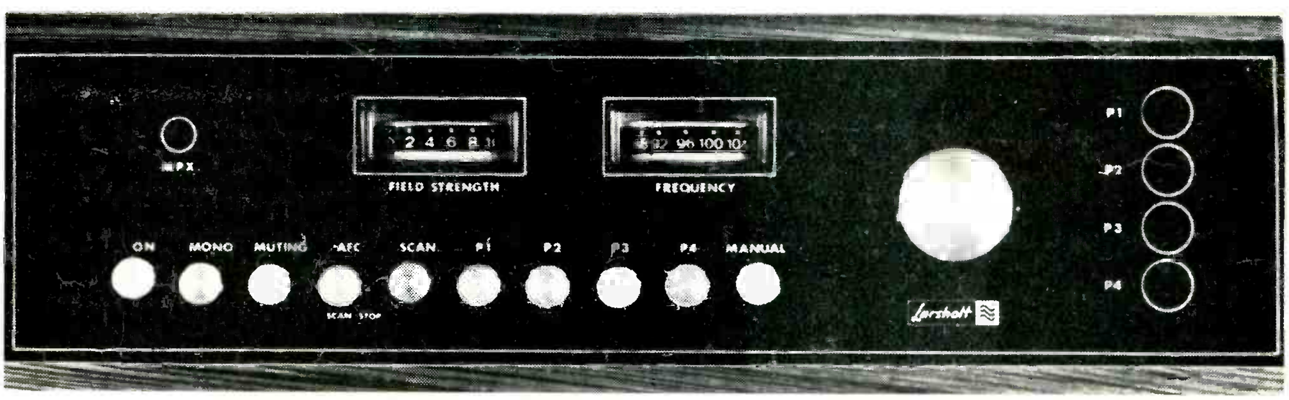


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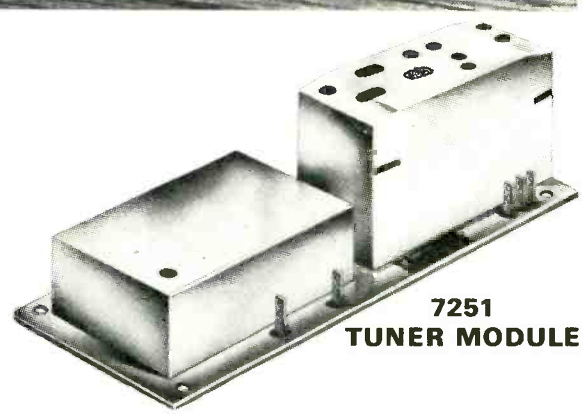

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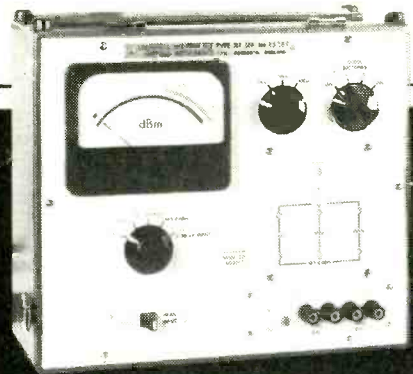


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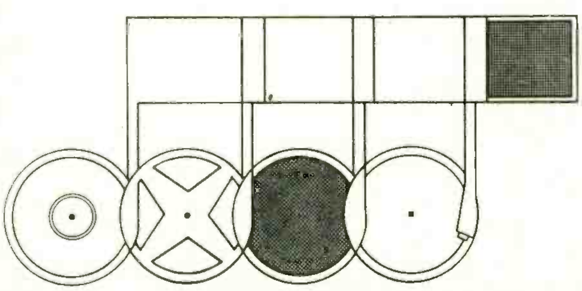

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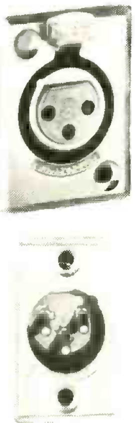

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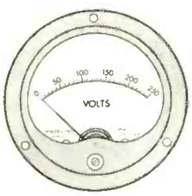


**Models 250 and 350**
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30 A dc
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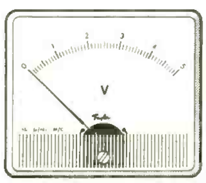
50μA to 50 mA ac (to 50 A with external transformer)




**Clarity range**
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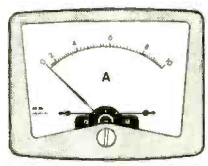


**Vista range**
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10 V to 1000 V ac (1000 Ω/V)
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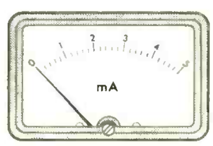


**Model 55**
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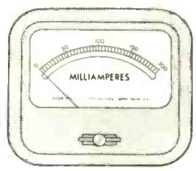
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
50μA to 50 mA ac (to 50 A with external transformer)




**Models 400 and 500**
10 mV to 1000 V dc (1000 Ω/V)
10μA to 30 A dc
10 V to 1000 V ac (1000 Ω/V)
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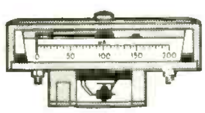
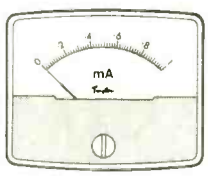


**Edgewise range (typical)**
50 mV to 400 V dc (1000 Ω/V)
50μA to 500 mA dc
10 V to 400 V ac (1000 Ω/V)
50μA to 5 mA ac




**Fyneline standard range**
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10μA to 30A dc
10 V to 1000 V ac (1000 Ω/V)
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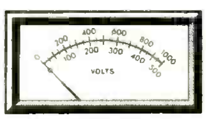


**Fyneline Pictureframe Window range**
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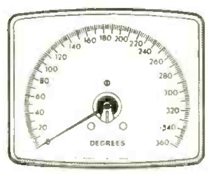


**Fyneline Wide angle range**
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500μA to 50 mA dc
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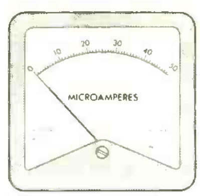
500μA to 50 mA ac




**Model 45**
10 mV to 1000 V dc (1000 Ω/V)
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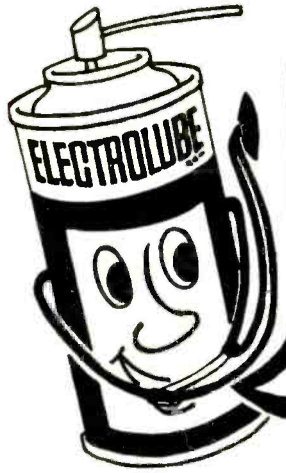


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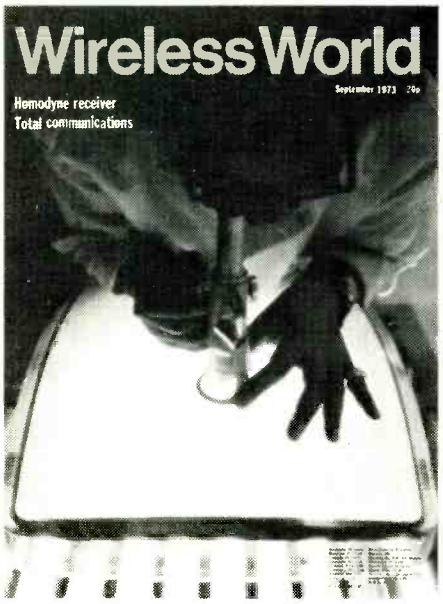
# Wireless World

**Electronics, Television, Radio, Audio**

*Sixty-third year of publication* **September 1973** **Volume 79 Number 1455**




**This month's cover picture** shows the inspection of colour phosphor dots on the faceplate of a Chromacolour television tube made by the Zenith Radio Corporation, U.S.A.

## Contents



### In our next issue
*(publication date September 17)*

**Digital voltmeter.** A $3\frac{1}{2}$-digit, dual-slope integrating voltmeter for alternating and direct voltage, with a sensitivity of 200mV full-scale. Uses filament-type seven-segment displays.

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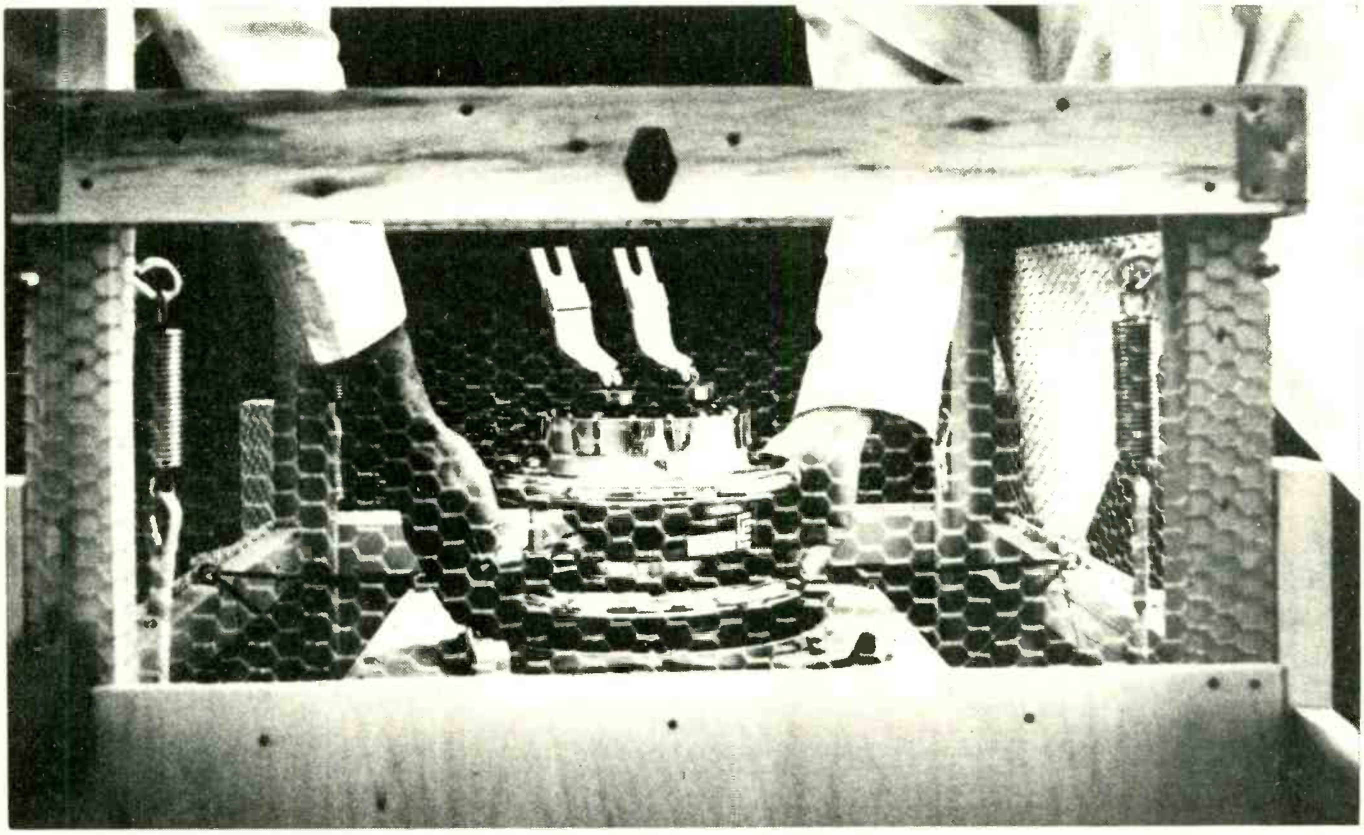

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| 4CX10,000D | 4CX10,000D CV6184 | 10 | 16 | 7.5 | 30/110 | 7.5 | 75 |
| 4CX15,000A | 4CX15,000A | 15 | 36.5 | 10 | 110 | 6.3 | 160 |
| 4CX35,000C | 4CX35,000C CV11107 | 35 | 82 | 20 | 30 | 10 | 300 |
| BR1161 | CV9343 RS726 | 35 | 100 | 14 | 10/30 | 11 | 155 |

| Ours | Theirs | Anode dissipation max. (kW) | Output power (kW) | Anode voltage max. (kW) | Frequency (MHz) | Filament ratings (V) | Filament ratings (A) |
|---|---|---|---|---|---|---|---|
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LAP 63

**WW—090 FOR FURTHER DETAILS**

Wireless World

## Electronics on the factory floor

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The purpose of Richard Graham's series of articles "Industrial Electronics" is, as the author has stated, to exemplify the possibilities of electronics in industry. To quote from his first article in the March issue, ". . . modern, solid-state electronics has improved on processes in use a few years ago by virtue of its incredible speed, reliability, low power consumption, small size and, in most cases, improved accuracy". Readers interested in the techniques used to obtain particular improvements may not be aware that there is a strong commercial force behind most of this technology — the need for greater productivity. In most cases the cost of the electronic equipment must be justified by the reduction in manufacturing costs obtained by its use.

Productivity is a measure of production efficiency — of a country, an industry, a factory, a process or a machine. Because it is a measure of efficiency it is expressed as an output/input ratio. The best known example is labour productivity, where the input is measured in units of labour and the output in units of product value (that is, money). Here industrial electronics can help to increase the output/input ratio by a straightforward reduction of the labour input, either in number of workers or in the proportion of skilled, highly paid workers. Or electronics can help by reducing the requirement for middle management workers, by simplifying and making more predictable the processes involved — e.g. by data acquisition and processing.

Labour productivity seems to get most attention because in the highly developed countries labour is a relatively costly factor of production. Also it is an emotive term carrying suggestions of labour saving, redundancy, Luddism and disputes between managements and employees. Less well known is productivity of capital — measured as a ratio of product output to capital input — which shows the efficiency of utilization of capital investment. Here electronics helps by providing control and programming systems, automatic handling and feeding devices, or other techniques which reduce the idle time of machinery or allow industrial plant to operate at higher speeds. It can also help to reduce expenditure on stocks and factory floor area by providing automatic equipment to give faster and more continuous production and therefore reduce work in progress and requirements for large stocks. In addition factory space can be saved by reduction of the areas normally needed for operators.

There is a third type of productivity, which shows the efficiency of materials utilization and is measured as a ratio of product output to materials input. Electronic techniques can help to reduce materials requirements and wastage in processing by providing automatic programming, inspection and quality control techniques which result in more uniform product quality, fewer rejects or less scrap; hence there is a smaller materials input to obtain a required volume of output product within specification. Electronic inspection or measuring instruments that will determine quantities faster and more accurately than can human operators will reduce the product quantity that normally has to be given away to ensure that goods have guaranteed weight or volume.

With all these possibilities it is sad that electronics has been so much mistrusted on the factory floor. This attitude is gradually changing, but there are many prejudices and traditional policies in the organization of industry still to be overcome.

# A Homodyne Receiver

*by J. W. Herbert**

The purpose of this article is to bring to the attention of the home constructor an as yet rather uncommon reception technique for a.m. signals which has significant potential for enhancing the performance of most receivers be they for short wave or broadcast listening.

## The problems of a.m. reception

The most common a.m. receiver circuit is the superheterodyne wherein the incoming signal is converted to some intermediate frequency before detection. Detection is usually by means of a diode-rectifier circuit which follows the i.f. stages. Other simpler receiver circuits are available to us however and these are shown in block form in Fig. 1 together with the superheterodyne.

The simplest of these receivers is the so called "crystal set". This name is a carry over from the early days of radio and as can be seen in Fig. 1 consists of an input tuned circuit feeding a diode detector. The rectified a.m. signal is filtered to remove any radio frequency component and the output passed on to the audio amplifier. Such a receiver is not very sensitive or selective but these characteristics can be greatly improved through the use of tuned radio frequency (t.r.f.) stages ahead of the detector. Such a t.r.f. receiver, as it is known, is quite useful but reception is still limited by the selectivity characteristic and the additional amplification causes overload problems in the presence of strong stations on adjacent frequencies. In an attempt to overcome these problems (amongst others) the superhet receiver was employed. Through the use of a converter stage the desired signal is relocated in frequency to become what is known as the intermediate frequency. In the i.f. channel, through multiple stages, as much amplification and selectivity as desired can be provided and furthermore, this characteristic is applied to all signals tuned. In the days when this receiver was first developed, the process of frequency converting was sometimes termed "heterodyning" and in order to obtain great selectivity the i.f. was often located at very low radio frequencies.

The superhet is by far the most common receiver configuration, particularly for telecommunications but like most systems exhibits its own peculiar set of disadvantages. These are significant when optimum reception of broadcast musical programmes is required by the audiophile. Bearing in mind the orders of audio frequency response, distortion and noise factors required in present day audio systems, the prime disadvantages of the superhet tuner may be summarized as follows.

- The superhet is the most complex receiver employing a number of separate stages (typically five), each with a separate role in the signal processing and incorporating multiple tuned circuits that must be aligned critically. Some of these are required to "track" each other as the receiver is tuned from station to station. This point alone makes the superhet the most expensive type of receiver.
- For optimum reception of programme, the receiver bandpass should be "flat" for 10kHz above and below the desired station carrier frequency as audio frequencies up to 10kHz are broadcast. If the receiver selectivity characteristic is such that the bandpass is less than 20kHz the treble frequencies broadcast will be lost in the receiver and/or the audio response will not be "flat". Bandpass restrictions usually occur in the selective i.f. and r.f. stages. Although this problem can be met with special block filtering in the i.f. and tracking bandpass couplers in the r.f. stages, the complexity, alignment and costs are very high. These techniques are therefore restricted to the most expensive tuners.
- The superhet generally employs a diode-rectifier type of detector stage (as does the crystal-set and t.r.f. receiver). There are two main reasons for this:

(i) it is simple and inexpensive,

(ii) the d.c. component in the output can be employed for automatic volume control purposes to stabilize receiver gain as station signal strengths vary. A prime disadvantage of this detector circuit is the high levels of harmonic distortion and intermodulation distortion it introduces to the recovered audio signal. For average levels of modulation percentage the diode introduces total harmonic distortion (t.h.d.) of typically 3% and at high modulation percentages 10% t.h.d. is not uncommon. These figures are based on valve receivers and are taken from reference 1. In order to reduce the diode detector t.h.d. the applied signal levels must have a large amplitude so that they operate mainly on the "linear" portion of the diode characteristic curve. Voltages up to 20 volts peak are not uncommon from the valve type i.f. but in the receivers of today valves are an exception. Transistorized stages, because of their much lower working voltages and circuit impedances, supply the detector diode with a signal that is restricted largely to the very non-linear diode

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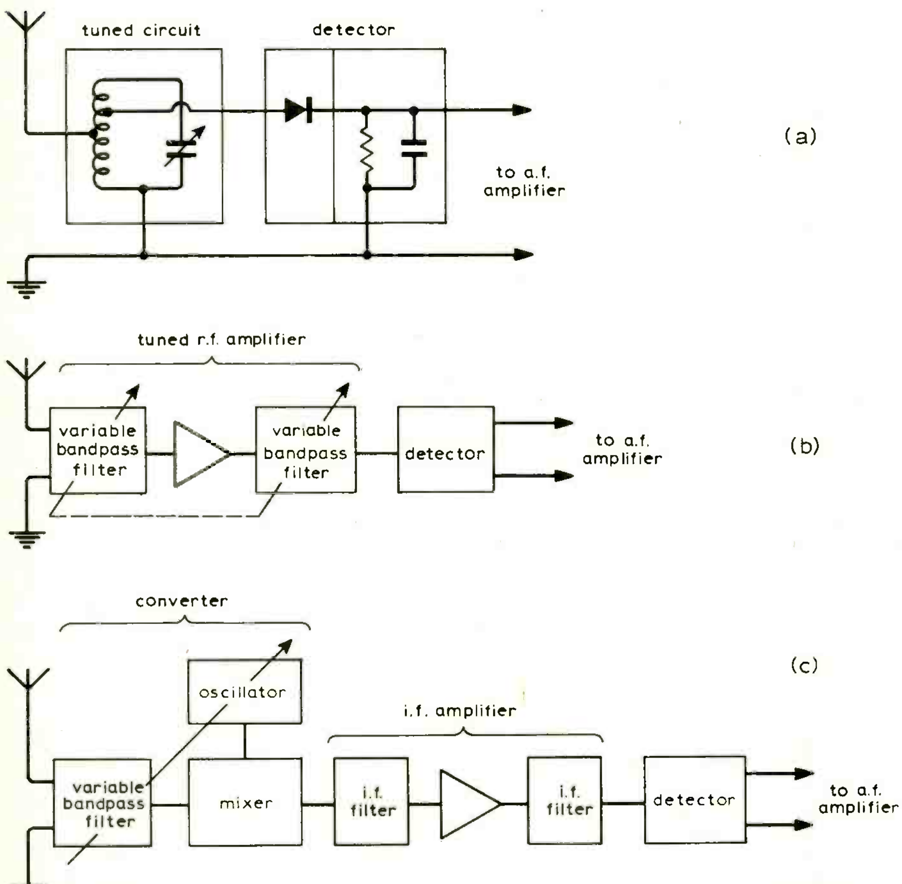


*Fig. 1. Broadcast receiver detector and demodulator systems.*

"turn-on" characteristic. This comparison is illustrated in Fig. 2 and results in generally higher levels of t.h.d. in the receiver.

It would appear then that the superhet has very real design problems when employed as a broadcast tuner. To the audiophile, probably the most noticeable deficiency is the restricted audio bandwidth followed by distortion and noise. A typical r.f. stage in a tuner with input and output tuned circuits will be sufficiently selective to cut the outer limits of the broadcast stations' sidebands significantly (i.e. the passband is much less than 20kHz). By the time the i.f. channel has passed the signal, further degradation can be expected. In a typical broadcast tuner the overall passband is about 8 to 10kHz total giving audio output up to about 5kHz before severe treble roll-off.

These facts may help explain why some component retail stores still offer crystal set and simple t.r.f. tuners as an accessory. Due to their broad tuning characteristic (i.e. poor selectivity) they offer a generally noticeable improvement in reception quality primarily due to their ability to recover most of the audio spectrum broadcast. Their effectiveness is limited however by the signal detection circuits they employ.

**Envelope detection of a.m. signals** Any amplitude modulated carrier wave has a "modulation envelope" which corresponds to the original modulating (i.e. audio) signal. Fig. 2 illustrates the action of a typical diode-rectifier type detector and it can be seen that the rectified output signal consists largely of the original envelope waveform — hence the general title of envelope detector for this system. It should be realized that the principle of envelope detection applies to a host of other detector circuits such as grid-leak, class B, infinite impedance, etc. Now since the envelope detector output is dependent upon the amplitude only of the incoming r.f. signal, there is no differentiation between the frequencies in the input signal be they desired or undesired (i.e. adjacent channel) frequencies. This can be illustrated with the example of a t.r.f. type receiver tuning into a 600kHz station. Due to the (purposeful) poor selectivity the passband response is still good 30kHz away where another station is broadcasting on 570kHz. The two signals are therefore impressed on the rectifier circuit, their amplitude variations causing a change in diode output current, both modulations being passed on to the audio stages. It can be seen that the only way to reject the undesired and interfering 570kHz signal is to tune it out with greater selectivity. Assuming both signals were of same strength in the receiving antenna, in order to suppress the 570kHz signal by 40dB, two tuned circuits would be required with a working $Q$ of about 100 each. The extent of the sideband cutting on the desired signal would be such that recovered audio frequencies at 3kHz would be suppressed by at least 6dB, rendering the receiver useless for musical programmes. Obviously then, receiver design using envelope detection must be compromised between achieving adequate selectivity and suppression of adjacent channel interference on one hand, and overall passband response for acceptable programme fidelity on the other.

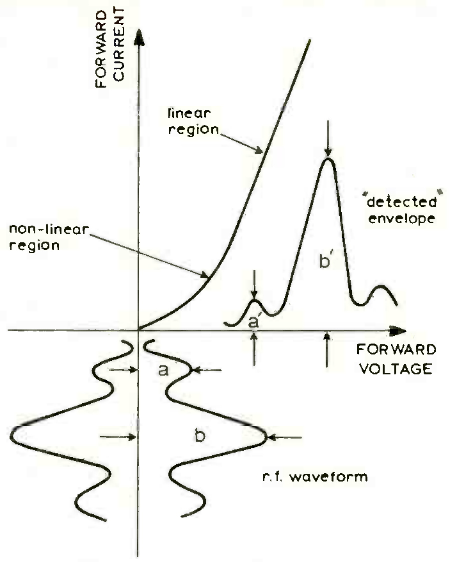

*Fig. 2. Diode detector characteristics and operation.*

**Product detection of signals — the "synchrodyne"** In search of a better "compromise" an engineer, D. G. Tucker produced a novel solution to the problem with his "synchrodyne" receiver in 1947. Tucker pointed out that if a broadcast signal is fed into a conventional superhet receiver in which the local oscillator feeding the converter stage is arranged to run at the *same* frequency as the incoming carrier, all of the side frequencies or sidebands associated with the signal carrier would appear as audio "beat-notes" in the converter output. This output then replaces the usual i.f. and in fact becomes the recovered audio signal. It is important to realize that in this case the incoming signal has not been detected as outlined previously, but rather has become displaced in the frequency spectrum to make it audible. Many readers will realize that this is the function of a so-called product demodulator in which the output signal is a mathematical product of the incoming signal and local oscillator multiplied together through the action of the converter stage. Let us take the previous example of the two broadcast stations on 600kHz and 570kHz and see how they are processed by this type of receiver. Once again the 600kHz signal is tuned in and because of poor selectivity, the 570kHz signal is also presented to the product demodulator. The local oscillator mixes with the incoming signal and any differences in frequencies appear as "beat-notes" at the output. The normal sideband components contain modulating frequencies extending up to ± 10kHz either side of the station carrier which has been tuned to zero-beat. The ± signs represent the upper and lower sidebands both containing the modulation, but due to the operation of the product demodulator these two components appear as two audio signals in phase at the output. Thus they reinforce each other in the form of a single audio signal. Of interest however, is the presence of the 570kHz interfering signal. Assuming its bandwidth is also ± 10kHz the lower frequency limit is 560kHz, the upper 580kHz. Since the receiver local oscillator is tuned to 600kHz, the interfering signal components will beat out with a frequency displacement locating them in the audio spectrum 20kHz to 40kHz. The interfering carrier would appear midway as a 30kHz whistle. The human ear cannot hear audio frequencies this high and furthermore it is easy to electronically filter the undesired frequencies, the interfering signal then, although present in the output, is inaudible.

With such a technique, receiver tuned circuit selectivity can obviously be reduced to prevent sideband cutting without fear of adjacent station modulations appearing as interference in the recovered audio signal. A second major advantage of the product demodulator is that since it is used to displace frequencies only, it introduces little distortion to the broadcast signal. Typical values are about 1% t.h.d. which is far less than the previously discussed envelope detector characteristic.

Unfortunately this receiver has several

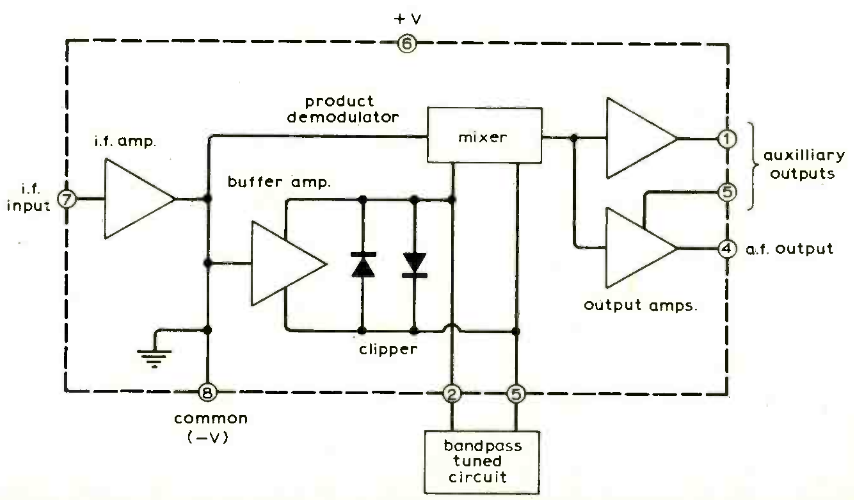

*Fig. 3. Block diagram of MC1330P i.c. demodulator.*

problems which have largely precluded its use on a domestic basis. The prime objection is that in order to recover the audio free of phase distortion it is important that the local oscillator be not only synchronized to the station carrier but must also be in phase with it. Tucker (and others), have developed circuits which give synchronization, but for reliable operation the circuits are more complex and critical than the rest of the receiver and in a way destroy the apparent simplicity of the system. Another problem is the inconvenience of tuning a receiver that gives a piercing audio whistle as it is moved from station to station, although complex muting circuits have been devised. We can see however, that the synchronous-heterodyne or "synchrodyne" is an obvious title for this receiver. Despite its limitations the synchrodyne is used primarily by broadcasting stations as a high quality "off-air" monitor receiver and anyone who has heard one operating will testify favourably to its capabilities in this application.

In more recent times electronic technology has grown very rapidly and many new circuits and applications have appeared within the framework of modern telecommunications systems. Two signal detection systems with common features that have appeared are the synchronous demodulator and the coincidence detector. In these, suitable circuitry provides for a product demodulator in which the local oscillator source is derived by extracting the incoming signal carrier only. The complexity of this arrangement is largely overcome through the use of integrated circuitry. In applying this concept to the synchrodyne type receiver it can be seen that employing a local oscillator is rather pointless as there is a perfect oscillator source in the received carrier wave. The problem is that it is amplitude modulated and of insufficient strength to use directly. If, however, it can be amplified and the a.m. stripped off, we have the ideal local oscillator source for product demodulation with the following features; it is inherently synchronized and phased to any station tuned in; no whistle or heterodyne will be encountered when tuning from station to station: thus the major disadvantages of the synchrodyne are overcome. Such a system once again effects frequency translation with the converter output or i.f. being one and the same as the audio signal. The base for the "same" is homo and the name "Homodyne" is therefore given to this inherently synchronized heterodyne receiver.

### A homodyne receiver based on i.cs.

Because of the wide bandwidth and low distortion capabilities of the synchronous demodulator, one version has appeared in i.c. form primarily for application as a video detector in colour TV receivers. The type number is a Motorola MC1330P[2] and a block diagram presentation is given in Fig.3 to show the circuit functions. Tracing the a.m. signal from the input terminal (Pin 7), the signal is fed into an "i.f." amplifier which provides two output paths.

One of these leads to the signal port of a product demodulator, the other feeds into a buffer amplifier. This amplifies the signal and applies it to a pair of diodes in a shunt clipper circuit, where the a.m. variations are clipped off the carrier wave after which it appears as a train of square waves. The "square wave" carrier signal is then injected into an external tuned circuit (Pins 2 and 3) where the fundamental component is extracted to provide a sine wave signal for injection as a local oscillator source to the product demodulator. The product demodulator output consists of beat-notes due to the difference in frequency between the a.m. sidebands and reconstructed carrier, these being amplified and fed out on Pin 4. At this point a low pass filter can be employed to in effect set the pass band response of the overall demodulator. The electrical circuit for the MC1330P is shown in Fig.4 and this can be tied to the block diagram by inspection.

At this point a most useful by-product of this form of demodulation can be brought out. As stated earlier the output of this stage is the mathematical product of the a.m. signal and reconstructed carrier. Since the signal carrier and the reconstructed carrier are inherently in

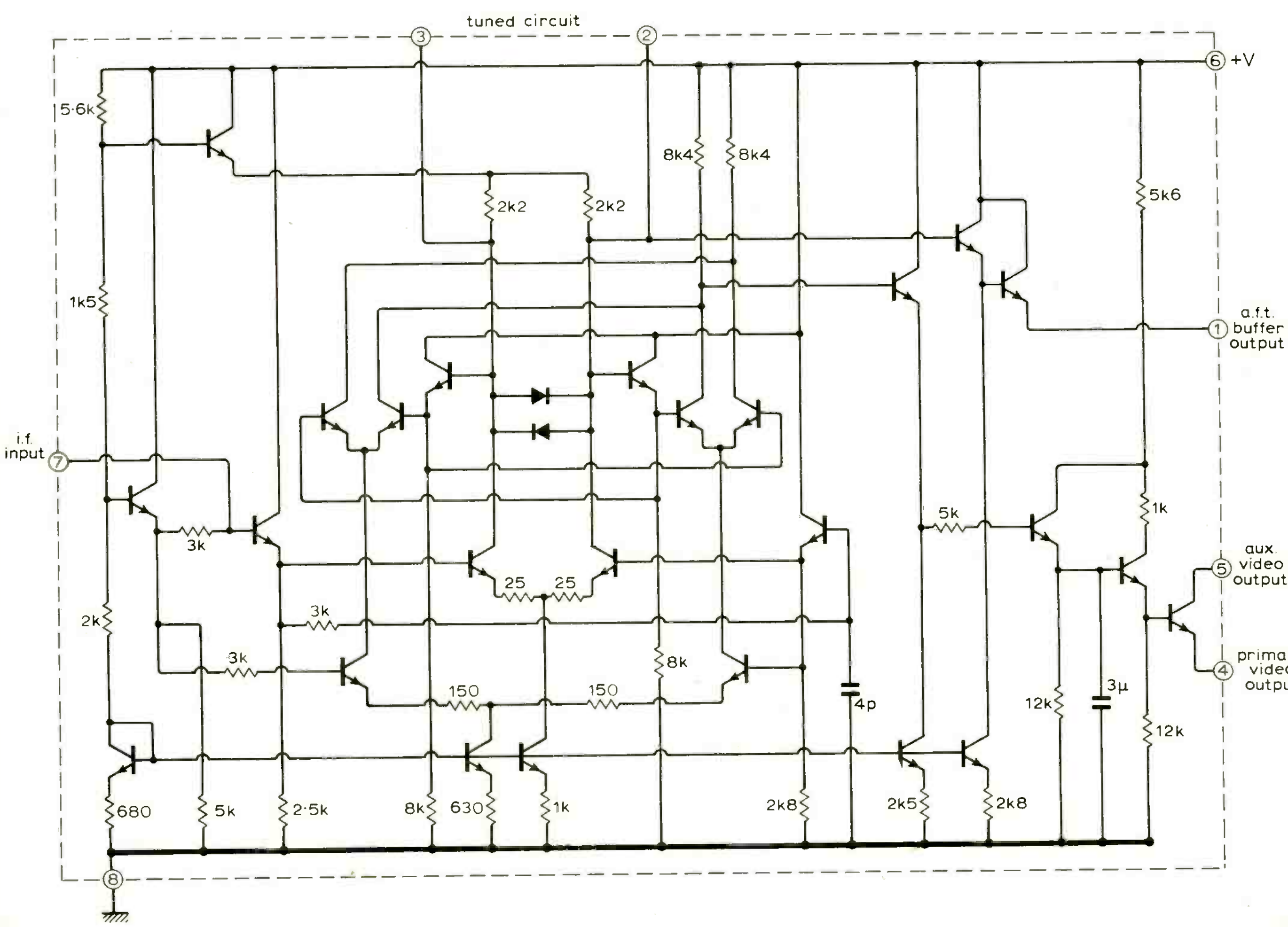


*Fig. 4. Circuit diagram of MC1330P.*

synchronism and phase we can call each, when no modulation is present, $\sin A$. The product detector output then is:

$$= \sin A \times \sin A$$
$$= \sin^2 A$$
$$= \frac{\frac{1}{2} - \cos 2A}{2}$$

The output signal then, as far as the carrier is concerned, consists of two components: $\frac{1}{2}$ is a d.c. component whose amplitude varies in proportion to the signal strength. Since the following amplifier is d.c. coupled, the output d.c. level shifts in accordance with station signal strength giving an automatic gain control voltage which can be applied back to the previous r.f. stage. The term $\frac{\cos 2A}{2}$ is a second harmonic of the carrier frequency. This is removed by filtering in the audio output circuit. This term can be significant however in connection with interference and this will be discussed later.

The circuit diagram, Fig.5, shows how all of these features have been combined in a practical homodyne receiver circuit that tunes the broadcast band. The antenna input is tuned by one section of a permeability tuning unit to select the desired frequency and feeds the signal into Pin 2 of the r.f. amplifier. This is an i.c. type CA3028A (R.C.A.) (Ref.3) operating in the cascode mode, the output load being an r.f. choke and the capacitively coupled input of the MC1330P.

Leaving the interstage coupling untuned ensures that no sideband cutting occurs at this point in the circuit. The detector tuned circuit is tuned by the second ganged section of the permeability tuner which must be aligned to track the input tuned circuit for optimum results. The demodulator output circuit (Pin 4) is filtered by a $0.01\mu F$ bypass capacitor which introduces attenuation to frequencies above about 12kHz. The output circuit is also separately filtered and decoupled to pass the d.c. component back to Pin 7 of the r.f. stage CA3028A for a.g.c. purposes. With no signal input, Pin 4 is at about 5V and when a signal causes this voltage to fall to about 3V, the a.g.c. action is established.

Alignment is achieved with the following procedure.

1. Connect a voltmeter between Pin 4 of the MC1330P and earth. With no incoming signal and a 12V power supply this should read about 5 volts.
2. The receiver tuning range is set by the antenna tuned circuit whose adjustable slug and trimmer capacitor should be adjusted to achieve a satisfactory tuning range at the low and high frequency ends of the band respectively.
3. Tune in a signal from a known station (or use a signal generator) at the low frequency end of the band and adjust the demodulator tuned circuit slug for minimum d.c. output on Pin 4. Then tune a signal at the high frequency end of the band and adjust the demodulator trimmer capacitor for minimum d.c. output on Pin 4. These adjustments interact somewhat and should be done alternately until tracking is well established.

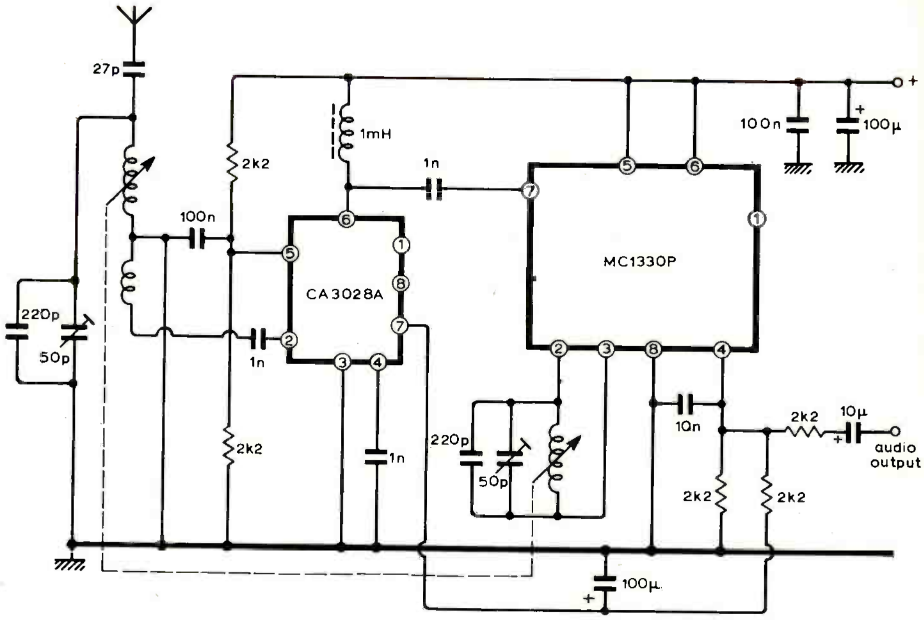


*Fig. 5. Circuit of the complete homodyne broadcast tuner.*

## Conclusions

The prototype Homodyne tuner has been evaluated with suitable test equipment with the following results. Frequency response (−3dB points): at 600kHz, 20Hz to 12kHz; at 1,400kHz, 20Hz to 15kHz; total harmonic distortion at 1kHz with 50% modulation, approximately 5%; a.g.c. characteristic threshold $500\mu$V, range about 40dB and a.f. output level, 500mV pk-pk.

Although the sensitivity for a.g.c. threshold may seem poor, in practice, local broadcast stations generally produce a quite high field strength and within a 20 mile radius of five broadcast stations tested, the a.g.c. was effective using only a six foot length of wire as an aerial.

Because of the wide bandwidth capability of the tuner it could be prone to 10kHz whistles. These are usually caused by adjacent stations whose carrier is located only 10kHz apart from the desired station. Since local stations have frequency allocations to avoid this situation it normally should not be a problem. In addition, the relatively poor sensitivity coupled with a.g.c. action reduces the strength of distant stations sufficiently to render them ineffective at producing whistles.

At some locations close to the author's home, a faint 10kHz whistle could be heard on a station operating on 570kHz. Since the nearest other station carrier is on 980kHz there seemed to be no obvious explanation. It should be recalled however that the product demodulator multiplies the signals fed to its two input ports as outlined previously. The second harmonic of 570kHz is 1,140kHz and is produced within the product detector (i.e. the $\frac{\cos 2A}{2}$ term).

This coupled with poor receiver selectivity allowed another more local strong station operating on 1,130kHz to find its way to the detector. The frequency difference is of course 10kHz and this appeared in the audio output. The level of the interference at the most unfavourable locations is not of annoying strength but it is worth noting that this effect can occur and is one of the limitations of this particular receiver.

Much further development is possible with the homodyne receiver and in particular the MC1330P i.c. could be applied to communications receiver circuitry. For example, the existing "homodyne" tuner could be made suitable for long distance reception by tuning the interstage coupling (i.e. replace the r.f.c. with a tuned circuit). This would greatly increase the sensitivity. Also as suggested, for a.m. reception, provide switched audio filtering to provide variable selectivity. By link coupling a b.f.o. to the associated tuned circuit the MC1330P functions as an excellent c.w.–s.s.b. demodulator. This has been proved by the author but with this simple arrangement, the a.g.c. feature is lost. More work could be done here to solve that problem. Further, it seems possible that by employing the automatic fine tuning (a.f.t.) buffer-amplifier (Pin 1) and coupling it back to a tap on the tuned circuit, a self oscillating product demodulator would be obtained.

As it stands the MC1330P is quite an effective slope detector of f.m. signals but for best results should be preceded by limiting i.f. amplifier stages.

With these fields open to the amateur experimenter it is to be hoped that further developments and applications of both the homodyne principle and the MC1330P i.c. will appear in print before too long. Certainly those who construct the tuner described in this article will acquire an interesting and rewarding introduction to the homodyne receiver.

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# Total Communications

## Development of "interactive" two-way television from cable distribution: combination with telephone systems

*by E. J. Gargini,** M.I.E. E., M.I.E.R.E.

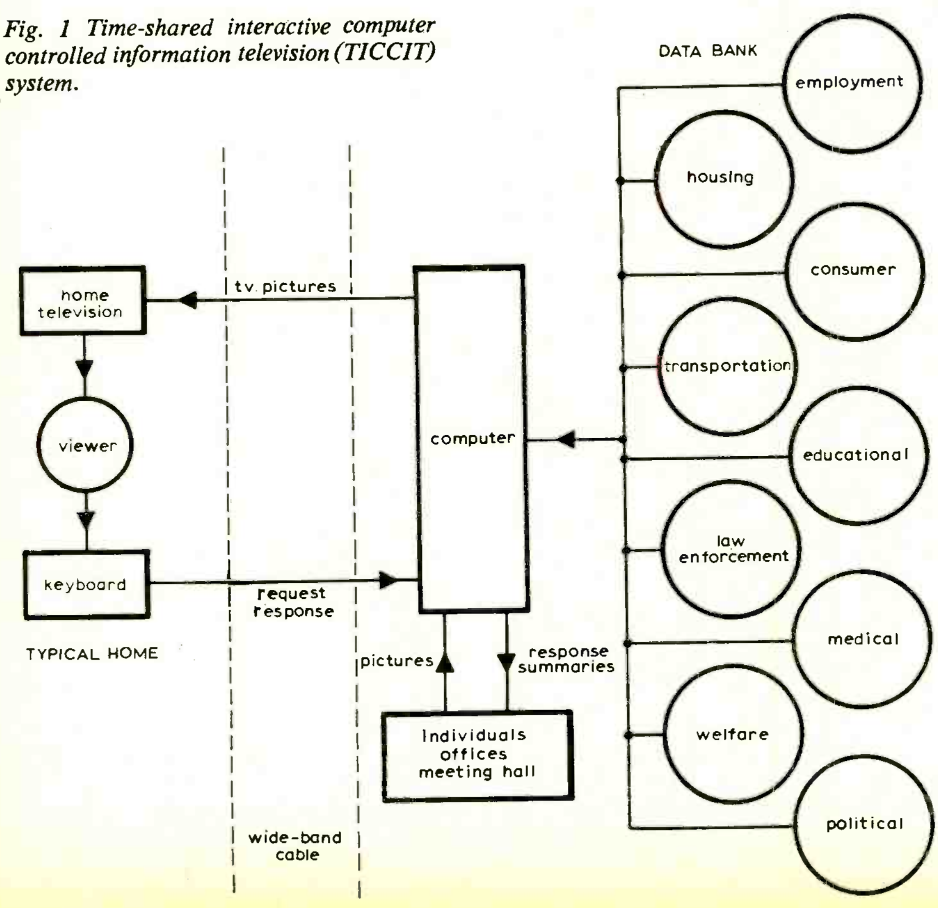
Wired broadcasting using modern cable technology has made possible an interactive or two-way facility for television. By this is meant techniques for obtaining immediate responses from viewers via, for example, push-button generated signals, voice signals or, if necessary, television picture signals, all originated at the subscribers' premises.

There are two main methods of distribution in wired broadcasting: (1) the wideband v.h.f. and hybrid v.h.f./u.h.f. method with "stacked" carriers, in which the programme is selected by tuning the receiver in the home; and (2) the h.f. multi-pair distribution method with a simpler, fixed-tuned receiver which is switched (in the home) to the required programme circuit. Interactive systems are being proposed and developed to suit both these branches of wired broadcasting technology.

Interactive systems using sequential signalling are being developed for combination with the wideband v.h.f. and u.h.f. coaxial distribution systems. These either use a portion of the spectrum at the low-frequency end of the cable carrying television signals or use a separate coaxial cable placed alongside the television distribution cable. Similar systems may be developed for the h.f. multi-pair technology, and these could either bring into use spare circuits or use a portion of the available spectrum of a cable circuit carrying television and sound signals. There are, however, limitations which apply to these systems, coaxial, double coaxial or h.f. multi-pair, inasmuch as there is a practical limit to the number of programmes which can be brought into every home and also because the bandwidth available for each subscriber-originated signal is small. This introduces a delay in signalling a response. Because each returned signal must be "stacked" in frequency or time only a limited number of subscribers can originate wideband television transmissions at any moment. These limitations are inevitable because v.h.f. and h.f. wired networks follow a "spreading-tree" configuration. This, while being fundamentally two-way (in that downstream signals applied to the centre of a system travel out to all extremities and upstream return signals applied to all extremities travel to the centre), makes it necessary, in order to recognize particular signals sent from a particular extremity, to introduce frequency and/or time division multiplexing of all signals returned from subscribers' premises.

* Rediffusion Engineering Ltd. This article is a shortened version of a paper by Mr Gargini, "The Total Communication Concept for the Future", published in *The Royal Television Society Journal*, March/April 1973.

*Fig. 1 Time-shared interactive computer controlled information television (TICCIT) system.*




### American v.h.f. communication systems

The Mitre Corporation, U.S.A., in their interim report entitled "Urban Cable Systems" (Nov. 1971)[1] point to the opportunity of making "revolutionary improvements in telecommunications for public uses" by providing an entirely new family of television related services to every home. The report is a quantitative study of the state of the art in equipment, software and programming, and includes a survey of the market possibilities for the new services.

A system is proposed for the District of Columbia, known as the Washington Cable Television Services system, to embrace an urban community of 700,000 people, and the design of this has been based on an analysis of the demographic, social, municipal and commercial characteristics of the District and the economic and service implications of these characteristics. The technical design of the two-way system, and kinds of services provided, are based on an experimental system Mitre have built and demonstrated in Reston, Virginia. The Mitre demonstration is of a number of one-way and two-way services using the Mitre Time-shared, Interactive Computer-Controlled Information Television (TICCIT)[2] system on the Reston cable system: see Fig. 1. This diagram represents several interactive communication systems and summarizes the Mitre proposals for the Washington Cable Television System.

Fig. 2 is a block diagram of the subscriber's home terminal equipment for the Mitre TICCIT system. The tests at Reston at present do not include equipment to the detail shown in the diagram. The demonstration equipment is simpler and the telephone network is in fact used as part of the two-way system experiment. This diagram, however, indicates the requirement in home terminal complexity for the fully expanded Washington Cable Television double coaxial system design. The equipment includes: a set top converter, which must have the very high channel selectivity required for adjacent channel operation on a v.h.f. stacked carrier system when this deals with nearly thirty channels in the band 60-300MHz; an A/B switch to transfer the set-top converter from cable A to cable B for receiving the second group of up to thirty channels; and a modem unit for dealing with the two-way facilities proposed for the Washington network. This modem unit is shown, associated with peripheral equipment which includes a "frame snatcher" (see below), an unscrambler and print-out devices.

Mitre have recently announced that a solid state "frame-snatcher" which can hold a page of alpha-numeric information will be available later at a price of about $500. In operation the TICCIT computer will address sequential fields of alpha-numeric information to particular subscribers: a group of 3,000 subscribers could have this information up-dated every two minutes for every allocated television channel. The unscrambler unit is intended to provide security either for the subscriber when he calls for private data, i.e. bank statements, or for the programme originator when transmitting pay television signals. The print-out device can include facsimile or other forms of hard copy.

The services offered by the system include television programmes on child care, health care, educational courses of all types, employment and housing, information on community meetings and locally originated television programmes. The system will cope with technical innovations such as computer-aided instruction, safety alarms, automatic meter readings and selective power control services. It also provides a basic network for automatic traffic control and public safety surveillance.

The Howard University in the U.S.A. conducted a market survey among householders to establish what services would interest potential subscribers and how much they would be prepared to pay for these services. Table 1 shows the results of this survey, based on 248 interviews with heads of households. Of all the families contacted, 85 per cent

**Table 1. Potential subscribers to wideband cable services: results of Howard University survey**

| Type of service | Type of system required | Percentage interested in specific service | Average fee they would pay |
|---|---|---|---|
| | | % | $/month |
| 1 Improved off-the-air signals | 1-way | 68 | 2.84 |
| 2 Special channels | 1-way | 63 | 2.18 |
| 3 New movies | 1-way | 75 | 2.67 |
| 4 Sport events | 1-way | 66 | 2.80 |
| 5 Educational services/CAI | 2-way | 71 | 2.22 |
| 6 Burglar alarm | 2-way | 68 | 2.86 |
| 7 Shopping aids | 2-way | 56 | 2.10 |
| 8 Subscriber polling | 2-way | 57 | 2.00 |

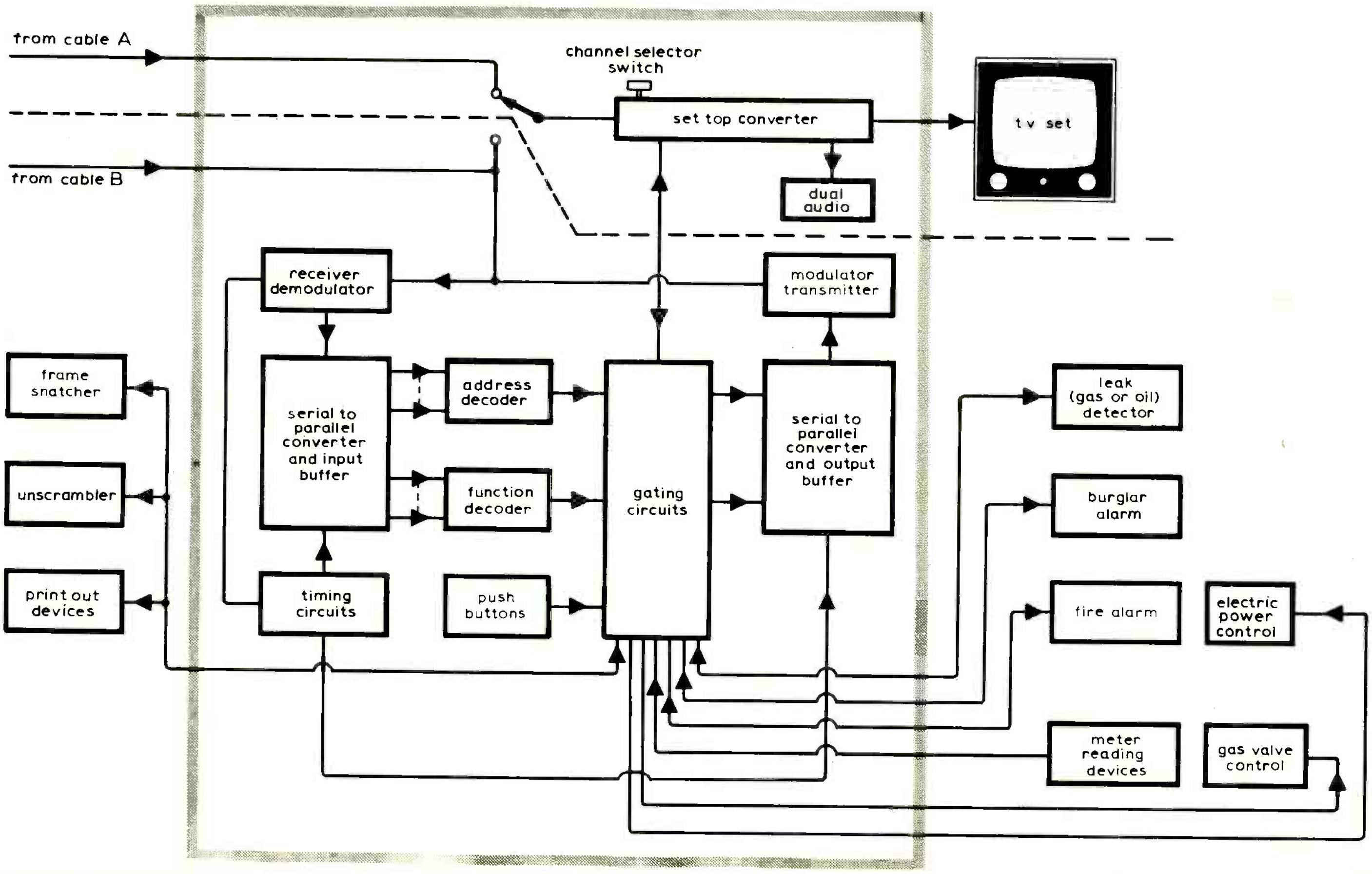



*Fig. 2 Subscriber's equipment for TICCIT system (see Fig. 1).*

expressed an interest in cable television and a willingness to pay a monthly fee of at least one dollar per month for at least one service. The most popular service was new films at 75 per cent. The least popular was shopping aids at 56 per cent.

Although Mitre have shown the new film service as a one-way system, in any practical pay television system some means must be provided for subscribers to decide whether or not to accept a charge, and this implies that a two-way facility must be available.

Fig. 3, taken from the Mitre report, shows the total annual subscriber revenue per householder that would follow from the expected utilizations of different combinations of services. Quite obviously the system operator would be interested in obtaining maximum revenue from the system by charging higher subscriber fees, with a consequent reduction in utilization of the system to about 50 per cent. This, however, would make the meter reading capability of the system far less attractive to the gas, electricity and water undertakings, who would only take interest and subscribe to a system which almost entirely replaced the present manual system of meter reading.

American interest in "total communication" systems is not restricted to the Mitre proposals for Washington. The Theta Com organization, a Californian company, have produced a system known as the Subscriber Response System and are conducting tests in El Segundo. Fig. 4 outlines the main parameters of the system[3]. Sixteen television and f.m. broadcast sound channels are distributed from the source in the band 52-300 MHz and passed to off-air receivers via a highly selective channel converter. Digital information on a carrier of 50 MHz is passed from the local processing centre to all subscribers, and responses from subscribers and subscriber equipment are transmitted back to the processing centre in the band 6-30 MHz, together with up to three television signals originated by subscribers.

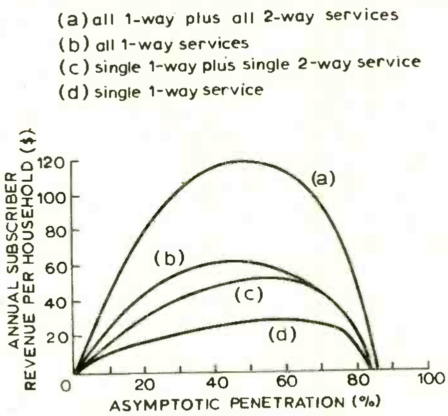



*Fig. 3 Revenue as a function of penetration for various combinations of service.*

The frequency separation and message routing system is also shown in Fig. 4. The digital data rate for downstream and upstream data is 1 Mb/s, and compensating delays are provided at subscribers' terminals to reduce the effect of propagation delays on the network. It is claimed that this, combined with special programming techniques, permits a total basic interrogation and response time of less than 2.5 seconds for 50,000 subscribers. Systems which do not eliminate the effect of propagation delay on the interrogation response sequence must allow a time delay at least equal to twice the propagation time between the computer and the most remote subscriber, to avoid interference between responses from two subscribers. The time required to poll 50,000 subscribers would increase (with 10-mile cable runs and without compensating delay) to 8 sec on the Subcarrier Response System.

The most extensive system concept, discussed in a report[4] by the Sloan Commission of the Alfred P. Sloan Foundation, is one under test and being demonstrated by Vicom Industries Inc.[5] This is intended to be a complete interactive digital system and has provision for controlling television channel use, data transmission and on-line interaction with the viewing audience by push-button keyboard response or by radio response, all these functions being controlled by a computer located at the "head" end. The outgoing command and control channel operates at a 1 Mb/s data rate and transmits 20-bit words at 40,000 words per second to the subscribers' terminals. These words are interpreted as either data for a terminal, commands to a terminal, or the "polling" of a terminal for a response. The terminal responds to every "poll" with its address and a single data character, and this returned information is sent at the 1 Mb/s rate used for the outgoing signal.

A key feature of the Vicom system is the control of who may view any channel. The converter is automatically disabled from the control centre whenever its channel selector is altered, and information about the new channel selector position is returned to the "head" end computer as a response to the next "poll". If the channel may be viewed by the subscriber a computer authorization signal is then transmitted which turns on the converter. The control of who views what is a requirement of pay television and of controlled group conferences.

The Vicom system also allows the chairman of a conference to control who says what by enabling or disabling the microphones of other subscribers on an individual basis. Anyone wishing to speak must indicate this by pushing a button.

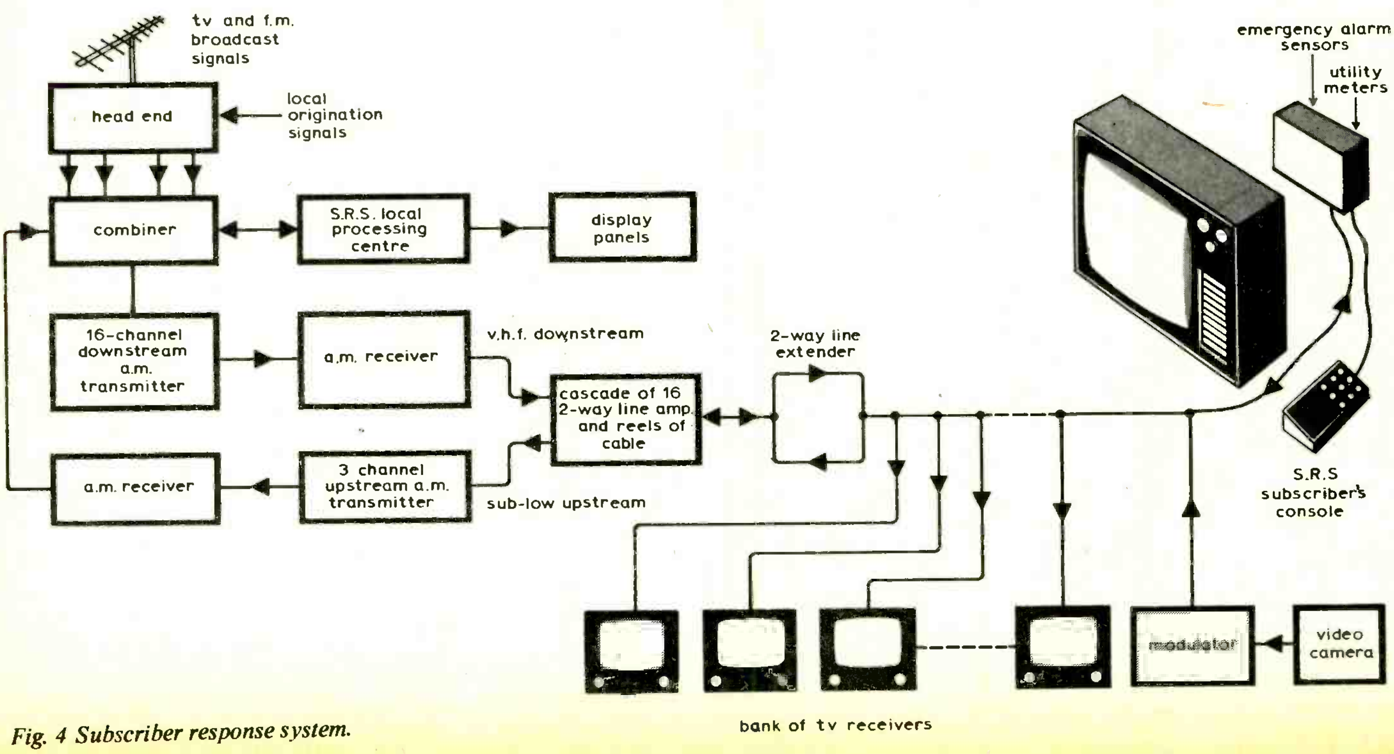



*Fig. 4 Subscriber response system.*

Two channels are allocated in the Vicom system for the command and response functions. Downstream signals are sent in the 108-114 MHz band and the upstream channel is in the band 6-10 MHz. All data transmission is on a time division multiplex basis and a word is 20 one-microsecond bits. Modems are addressed at a rate which depends upon the particular action requested by a subscriber and is under the control of the head-end computer. The rate is between one and five per second for routine "polling", and for full screen displays of alpha-numeric information up to 5000 words per second can be transmitted to a single subscriber. Extensions to 30,000 words per second are possible.

The computer capital cost per subscriber based on 4000 subscribers is quoted[4] as $5-$15 depending on the type of data service rendered. The present cost of a home terminal is estimated at $265 and in large scale production about $135. This home terminal comprises a keyboard entry unit with 12 momentary-contact keys, a microphone and a 25-channel converter that may be enabled and disabled under head-end control. Later models will include storage for up to 16 alpha-numeric characters which can be viewed on the television receiver. Provision is made for attaching a variety of peripheral devices such as television cameras, full screen alpha-numeric generators, hard copy printers and full keyboard typewriters.

Telecable Inc.[6] have arranged for tests of the Vicom system in Overland Park, Kansas. The tests include home instruction for disabled children and home shopping demonstrations in co-operation with the Sears Roebuck company.

**Central switching systems**

The switched telephone system for point-to-point communication follows a "hub and spoke" network configuration and each circuit from the "hub", or exchange, is terminated at a particular subscriber's premises. There is thus no requirement, in general, for circuits to handle information from more than one network extremity, and thus no requirement for time division multiplexing at subscribers' premises.

What are called television switching centre systems are "hub and spoke" arrangements like the switched telephone network. Examples of these are the Dial-a-Program system — a development of the h.f. system in which the subscriber's selector switch is placed at a programme exchange and operated by a dial in the home — and a similar American system called Discade[7] which employs coaxial cables. An important feature of the television switching centre system is that the television programmes made available at programme exchanges can be increased in number without modification of equipment in the home. It is, of course, necessary to increase the number of cable circuits linking exchanges, typically 10 per cent of the total cable route distance, and to add extra programme lines at the exchanges. But both these operations entail no disturbance to the subscriber network or equipment, which is analogous to the expansion of telephone services. To complete the analogy, the television switching centre system has the important limitation, in common with the telephone, that the number of subscriber cable circuits (i.e. output lines provided) is a direct function of the number of subscribers that can be served, and a sufficient number must be installed at the outset to cater for future development.

American opinion on the relative merits of the tree structured "stacked" carrier system and the "hub and spoke" central switching system is varied. In the report by the Sloan Commission on cable communication entitled "On the cable — the television of abundance", the main advantages of the central switching system such as Dial-a-Program and Discade are given as:

- Almost complete immunity to the interference effects associated with the multiplexed v.h.f. system.
- The ability to use simplified tunerless television receivers.
- The better security of the system to unauthorized use, i.e. switching systems require connection somewhere of a physical device, whereas in the v.h.f. "stacked" carrier system the subscriber does not need a special physical device but only modification of the legally connected device he already has.
- The ability to provide a separate, full-bandwidth upstream channel from every subscriber.

On the other hand the Sloan Commission finds the main advantages of v.h.f. multiplexed systems to be:

- There is no "real estate" problem because the distribution amplifiers can be mounted on the poles which carry power distribution cables, transformers and the telephone network (a feature of most American towns), whereas in the Dial-a-Program system the local exchanges must be installed at the outset because they also house trunk repeating equipment, and in settled communities site acquisition can be difficult.
- For the moderate channel capacity considered necessary v.h.f. distribution systems are cheaper with respect to network and distribution equipment costs.

The Sloan Commission has also speculated on the future development of point-to-point video services and considers this would represent a major cost escalation of subscriber equipment by at least $500 for the modulator and camera in large quantity production. They go on to quote a study by Complan Associates, which estimated the added capital cost of a complete nationwide narrow band (1 MHz) videophone service for 100 million subscribers to be $3000 per subscriber — about five times the existing voice-grade telephone service — and that a high quality 6 MHz service would cost about $12000 per subscriber. In both estimates "out of plant and local exchange costs" account for between one-third and half of the total. Thus a high quality, two-way videophone service would cost an amount just within that of a typical c.a.t.v. head end dealing with 10,000 subscribers — at least $4000 per subscriber and about 20 times more than v.h.f. stacked carrier systems. No estimate is given for the cost of a central switching system such as Dial-a-Program in this context but it would be substantially less.

It would be fanciful to imagine that wide-band, or for that matter narrow-band, videophone will have much application in the foreseeable future by the general public, because of cost. It is possible, however, for a wide-band videophone service to be developed for specialist applications such as "tele-medicine" and possibly at least within local communities.

Marlarkey Taylor and Associates of Washington, D.C., have produced a survey report distributed by the National Technical Information Services of the U.S. Department of Commerce entitled "Pilot projects for the broad band communication systems".[8] The report considers the modification and addition to the tree-structured v.h.f.-c.a.t.v. system to achieve two-way communication and points to the difficulties and complexities of the home terminal equipment required in what they describe as "these party line systems". They consider that the type of communication contemplated does not even approach conversation or narrative, but since the computer is able to interrogate all subscribers in a very short time it is possible to send alpha-numeric messages using TWX or other codes. Also, with suitable computer programming, messages could be transmitted for subscriber communication. Mention is made in this report of work in the television receiver industry on television tuner design to suit the adjacent channel etc. requirements of c.a.t.v. systems dealing with more than 12 programmes per cable.

The report includes a cost comparison between double coaxial tree and Discade and Dial-a-Program hub systems, dealing with 24 channels to 5000 subscribers. This indicates that switched systems at this channel capacity cost about twice as much as tree systems. Off-air receivers were assumed as being used in both types of system and the comparison included no two-way facilities. The report, however, drew attention to the advantage of the switched system in that cheaper simplified receivers giving high quality pictures, not necessarily restricted to N.T.S.C. standards, could be used and that the remote switching feature permits maximum security for pay television etc. without the necessity for scrambling.

In the cost comparison all cabling was assumed to be carried overhead on messenger wire strung between utility poles. These poles also support the active equipment used in the v.h.f. tree distribution system. There is, however, a growing tendency to place networks underground in new communities and this would reduce the cost differential between the tree and hub systems.

It seems appropriate at this point to present the case for a central switching system and to list the facilities which appear to be of most value to a developing society. I believe that a wired central switching system can overcome the natural barrier of the restricted capacity of radiated over-the-air broadcasting and make it possible to look forward to a future where television can be a selective medium in addition to a mass medium that is as open and unrestricted as the printed word. This argument leads directly to the requirement for a two-way visual communication system and for an electronic library or libraries capable of storing vast quantities of information in alpha-numeric form and dealing with a very large number of stationary or moving television pictures. All this information would have two main purposes: (1) education and instruction,[9] and (2) entertainment and information.

Fig. 5 depicts the situation in education envisaged for the future. The pupil is not entirely taught by television but the role of television is certain to be much greater in the future.

Fig. 6 depicts a personal view of the ordering of services dealing with entertainment and information for the future. The central base, labelled entertainment/community affairs resource centre, is in principle the central switching system. The diagram includes, in addition to the home, other access points shown as kiosks which might be placed in shopping areas. These kiosks may also find application in future transportation schemes in which the routing of public transport vehicles is controlled directly by public request.

A central switching system with all the facilities outlined in Figs. 5 and 6 must be economically viable. The user must pay for it, either indirectly by taxes and in purchasing advertised goods or services, or by direct billing. From the pay-television aspect of direct billing, the system must also have commercial security in the sense that the originator of a televised programme must be sure that only those who are prepared to accept a charge and pay are able to view the programme. It must also be possible for the head of the household to be secure in the sense that he can authorise the expenditure incurred and what is to be watched — by turning, for example, a pay television key.

Some information and instruction must be restricted at the source, i.e. information intended for specialist users who require high security, such as bankers, stockbrokers, police and doctors. The system must therefore include a "programme denial" feature which cannot be bridged electronically by someone in the home.

A central switching system can meet these requirements.

*(To be concluded)*

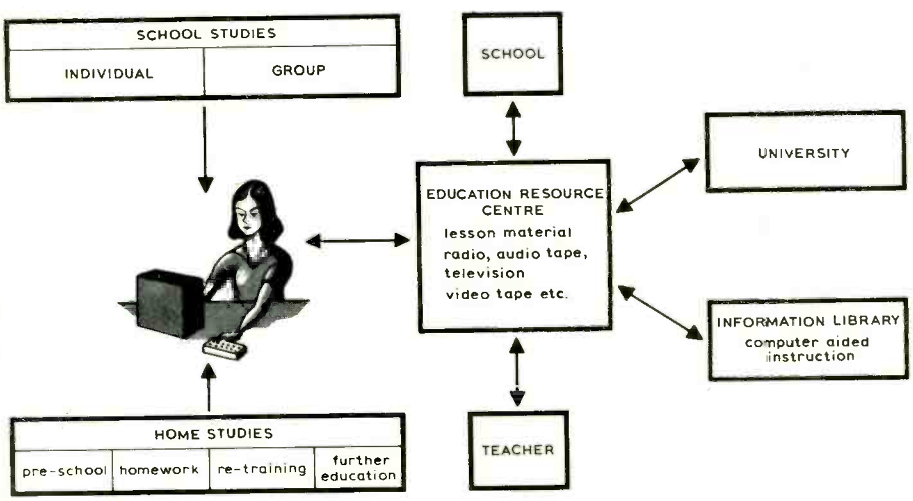



*Fig. 5 Future educational service.*

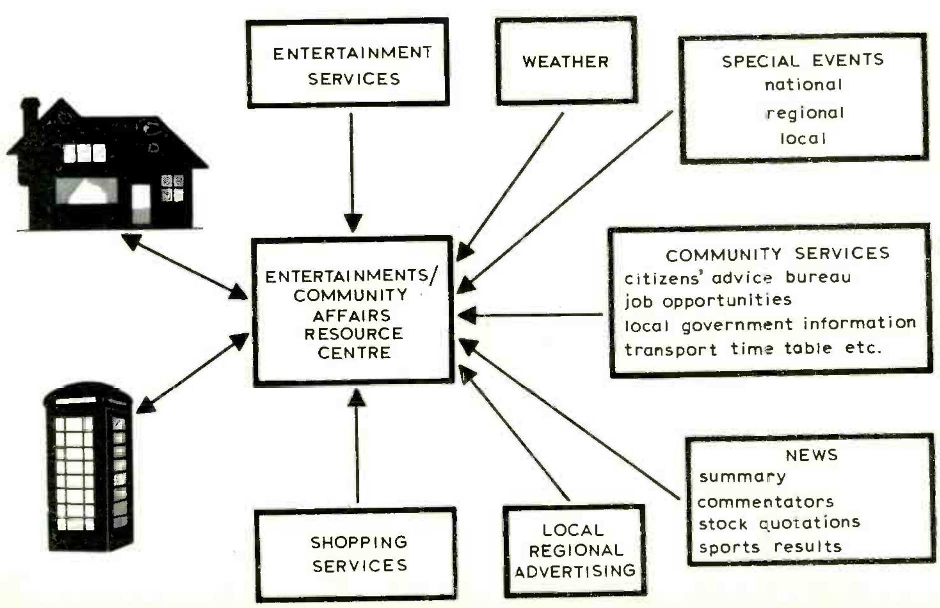



*Fig. 6 Future entertainment and information service.*

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1. W. F. Mason. "Urban Cable Systems — an interim report (M71-64)", Mitre Corporation, Washington, D.C., Nov. 1971. Also W. F. Mason and S. Polk, "Revolutionising home communications (new techniques for using computers with cable television) (M72-38)", Mitre Corporation, presented at the 1972 IEEE Intercon, 20th-23rd March 1972.
2. K. J. Stetten. "Ticcit: A delivery system designed for mass utilization (M71-56)", Mitre Corporation, Oct. 1971.
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7. J. E. Ward. "The Ameco Discade System", Appendix A, Report of the Sloan Commission on Cable Communications, McGraw Hill, 1971, p.199.
8. "Pilot projects for the Broadband Communication Distribution System PB208 913 (Nov. 1971)", Marlarkey Taylor and Associates, Washington, D.C., distributed by National Technical Information Services, U.S. Dept. of Commerce.
9. Prof. G. Pask. "Computer Assisted Learning and Teaching" (System Research Ltd), Proceedings of a seminar on computer based learning systems, Leeds University, 8th-12th Sept. 1969, published by the National Council for Educational Tech., London.

# Motional Feedback Loudspeaker

## Low frequency reproduction from a small enclosure

The principle of deriving a corrective electrical feedback signal from a moving loudspeaker cone has been known for some time[1]. Several systems have been developed based on this principle and recently Philips have released information on a new "motional feedback" loudspeaker system (22RH532/00) which has been under development for several years. Comparative listening tests indicated that Philips have achieved a high degree of success with a controlled frequency response for the lower audio frequencies. The system, whose volume is a mere 15 litres (38 × 28.5 × 22cm external dimensions), is designed with a 12dB/octave low frequency cut-off at 35Hz.

### Feedback principle

A loudspeaker cone does not always move in the pattern which its input signal intends. Distortion is generated — especially at low frequencies — by the resonant condition of the system and also by

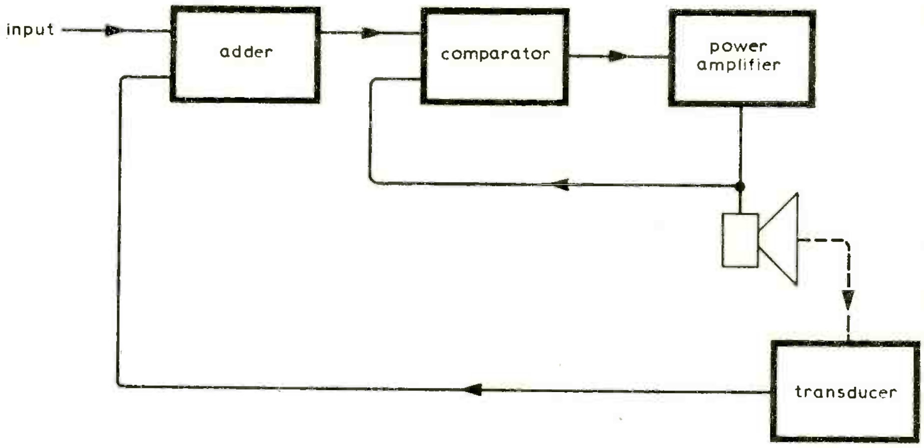
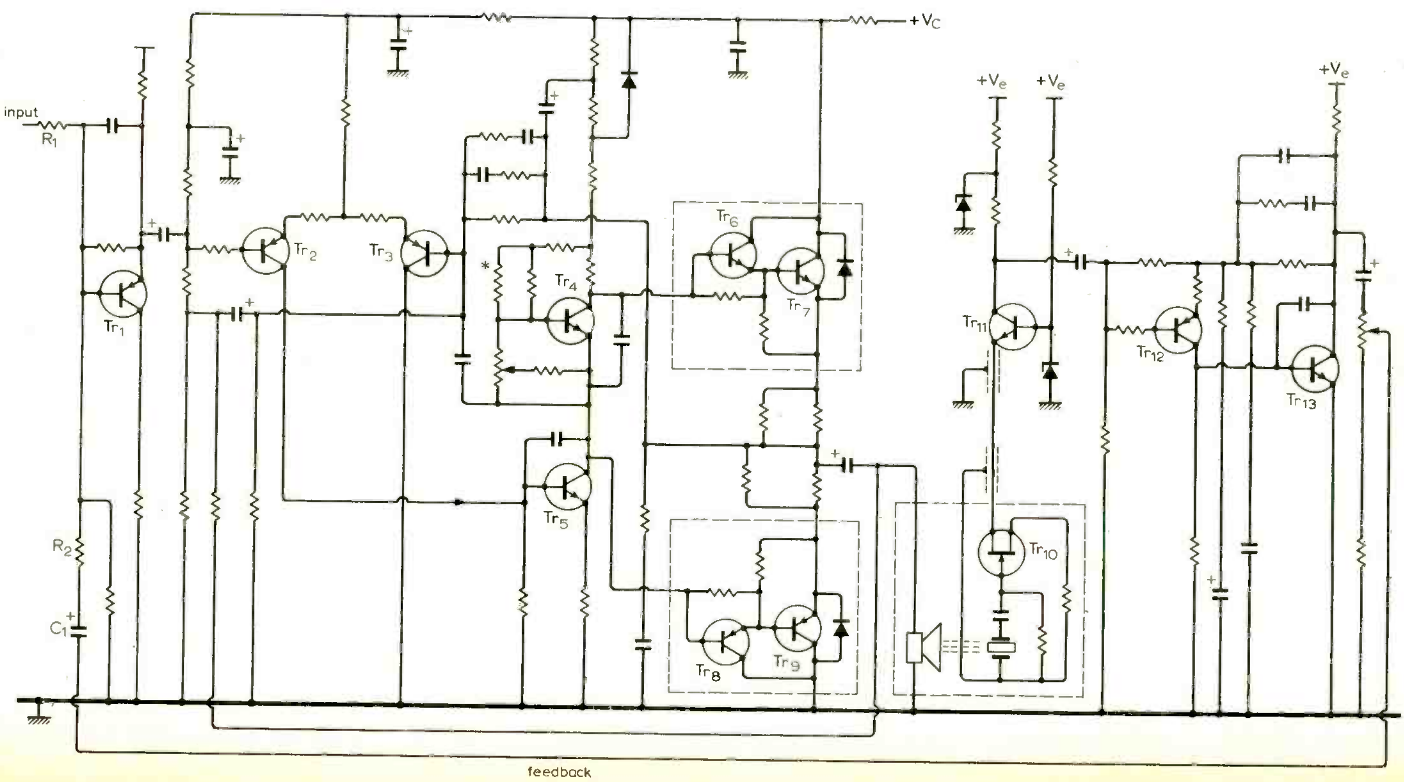



*Fig. 1. Block diagram of the method used for deriving a corrective signal from a speaker's movement.*

*Fig. 2. Circuitry in the Philips motional feedback system which is directly involved with the principle outlined in Fig. 1. Resistor * has a negative temperature coefficient.*



the inability of the system to cope with the condition cone velocity $\infty$ frequency$^2$ for a constant sound pressure level. If the motion of the cone can be sensed in some way to generate a current proportional to the speaker's acceleration, then this can be compared with the input signal and a corrective signal generated to force the cone to move in the manner originally dictated to it.

Fig.1 outlines the motional feedback system. Movement of the loudspeaker cone is transduced into an electrical analogue signal which is fed to an adder with the original input signal. The resultant signal is then compared with the current which flows through the loudspeaker voice coil and a corrective current is generated if the loudspeaker cone acceleration (proportional to the feedback signal) does not follow the input signal.

Several methods of deriving a feedback voltage from the speaker cone movement have been tried. A voltage may be derived from the displacement of the coil or from its velocity. Velocity feedback by means of an equivalent series inductance, or displacement feedback by means of capacitive variations have the disadvantage that a stationary reference point is required. This and other difficulties can be avoided by a device which measures the acceleration of the speech coil. The Philips system uses a PXE ceramic acceleration transducer — of the type used in ceramic pickup cartridges — which is clamped to the cone with the aid of two small rubber blocks. The element produces voltage which is proportional to the acceleration (inertial force) of the cone, and, provided the cone acts as a piston, the cone's acceleration is proportional to the acoustic oscillation. A drop of soldering tin is deposited on each side of the ceramic element to hold the attached wires in position. Connected to the output of the PXE transducer is an amplification and frequency correction stage. The resultant signal is fed back to the adding circuitry.

### Circuit description

All crossover, power amplifiers and feedback circuitry for the three drive units in the Philips system is contained within the loudspeaker cabinet. The circuitry associated with the motional feedback loop and the bass driver power amplifier is shown in Fig.2. The input signal is taken from an 18dB/octave low pass filter and a 12dB/octave high pass filter, so that the band of frequencies fed to the bass unit circuitry is approximately 35 to 500Hz. This signal is fed to the adding circuitry ($Tr_1$), to which the feedback signal derived from the acceleration transducer is also applied. The latter arrives at the base of $Tr_1$ via $R_2$ and $C_2$ and the input signal does so via $R_1$. The gain of the adding circuitry is approximately unity. A high-impedance ceramic crystal is matched to the feedback circuitry using a junction f.e.t., $Tr_{10}$. If the gate impedance of $Tr_{10}$ is to be kept high, the drain-source voltage must not exceed a certain value and to ensure this condition, a zener diode is used in conjunction with $Tr_{11}$. Before the feedback signal is fed to the adder stage, the amplitude response is corrected by the arrangement of $Tr_{12}$ and $Tr_{13}$. Down to approximately 80Hz, the correction stage has a flat amplitude response, but below this the signal has a slope of 6dB/octave, the reason being that feedback at the resonant condition (also at about 80Hz) may cause the amplifier to become unstable.

The input signal is fed from the adder to a 40W amplifier ($Tr_6$-$Tr_9$) which drives an 8in bass unit. The signal which flows through the speaker voice coil is used to provide an input to the base of $Tr_3$, which forms part of a differential amplifier with $Tr_2$. The input to the base of $Tr_2$ is the sum of the input signal and the motional feedback signal. Thus the speaker's movement is compared with the driving signal and a corrective current is generated if necessary.

#### References

1. Klaassen, J.A. and de Koning, S.H., "Motional feedback with loudspeakers", *Philips Technical Review*, Vol.29, pp.148-157.

## Books Received

**Data Telecommunication** by R. N. Renton gives an account of all techniques involved in interconnecting data systems and computers. It describes the various DATEL services recently introduced by the Post Office, special attention being devoted to error-detecting and error-correcting codes and to systems designed to combat errors due to transmission. The recently adopted CCITT/ISO/ASCII seven-unit code is presented. The essential line characteristics for satisfactory data transmission at various speeds are specified, full references being given to international (CCITT) standards. The important characteristics of national and international line circuits for data transmission are specified. Basic network plans for the U.K's STD system, and for worldwide telephone and telex exchange switching are illustrated with maintenance and fault testing procedures also fully covered. Although written for telecommunication engineers and students, this book will also be of interest to computer designers and users. Price £2.75. Pp.227. Sir Isaac Pitman and Sons Ltd, Pitman House, Parker Street, Kingsway, London WC2B 5PB.

**Colour Television — Questions and Answers** by J. A. Reddihough gives a simple, practical account of colour TV transmission and reception for the enthusiast, technician and service engineer. While the emphasis is on the techniques used in PAL colour receivers, the book necessarily begins by covering the principles of colour and the way in which a compatible colour signal is transmitted. The next sections deal with the shadowmask tube and the circuits needed to modulate it, and how the receiver decoder processes the composite transmitted waveform to produce the signals required by the shadowmask tube. The final section is devoted to convergence circuits and the various convergence adjustments that are involved. Price 75p. Pp.108. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

**Electrical Transducers for Industrial Measurement** by P. H. Mansfield describes the principles of operation of the main types of instrument transducer for measuring a wide range of physical variables such as pressure, temperature, speed, flow, displacement, viscosity and density. Details of the range, accuracy, and linearity are given in each case. Since new applications for transducers are constantly being discovered, a useful inclusion is a "Measurements Method Chart" which shows methods for converting into an intermediate output and thence to a final electrical output of physical quantities that cannot be directly measured. To enable the reader to select the most suitable instrument for a specific purpose, a directory is included of transducer manufacturers or suppliers in the U.K., which lists readily available devices with their mode of operation. The book is a guide for engineers involved in instrumentation and control and to students taking degree or HND subjects in these courses. Price £4.40. Pp.281. Butterworth & Co. Ltd, 88 Kingsway, London WC2B 6AB.

**Solid-State Circuits** by G. J. Pridham provides an introduction to modern semiconductor theory and practice. It is a sequel to "Semiconductor Circuits" written by the author in conjunction with J. R. Abrahams, but while embodying certain features of that book it also lays considerable emphasis on field effect transistors and integrated circuits. The text is divided into three sections. The first is concerned with the basic physics of semiconductors, diodes and transistors and the construction and characteristics of devices including integrated circuits. The next section deals with the fundamental use of semiconductor devices in rectifier, amplifier and oscillator circuits. One chapter specifically deals with the high frequency use of transistors and in all examples, designs from device characteristics are included. The final section develops the a.c. equivalent circuits of transistors. Price £2.50 (hardback), £1.80 (limp). Pp.184. Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 0BW.

**Illustrations in Applied Network Theory** by F. E. Rogers. Network theory has vital practical objectives: the analysis of given networks, or the synthesis of networks to fulfil given requirements. Though synthesis and analysis are converse in procedure, both are bound by the same circuit laws. This notion, together with duality, permeates the book in which a hundred numerical and algebraic illustrations exemplify practical circuit problems. Chapter headings include: general principles for passive and active network analysis; transient response and its correlation with frequency response; simplifying procedures, theorems and equivalances; power transfer and allied concepts; examples of non-linearity and the response of networks to non-sinusoidal waveforms and finally electronic amplifiers with feedback circuits. The book is primarily intended for the intermediate years of degree courses in electronic and communication engineering but it will also be of value to students following similar courses, such as HNC, HND and CEI. Price £5.00 (hardback), £2.50 (limp). Pp.228. Butterworth & Co. Ltd., 88 Kingsway, London WC2B 6AB.

# News of the Month

## Optional radio broadcasts

Hi-Low, standing for High Listener Option Radio, is a system of f.m. broadcasting proposed by David Williams of Matrix Enterprises for the transmission of two simultaneous sound broadcasts (see August "News" p.392 for tests made by the B.B.C. of the SCA-type system). One of the programmes can be in stereo and is compatible with standard receivers. The second programme is a time-shared sequence of items — the idea being that these items would be for minority groups within a wide audience receiving the compatible programme. The time-shared programme is accompanied by an electronic control signal which is made to change according to the kind of programme item which is being broadcast.

According to the technical information supplied in a pamphlet about the system prepared by Matrix Enterprises, the aim is as follows. The transmitter operates in the v.h.f. band and is frequency-modulated with a signal which may be considered as consisting of three components.

Component A is a sound signal conventionally prepared for v.h.f./f.m. broadcasting, and which may be a stereophonic signal encoded according to the pilot-tone system. Component B is a low-level 19kHz tone which is amplitude-modulated with one or more "key frequencies" of less than 1kHz. If component A is a stereophonic signal, the carrier frequency of component B serves as the stereo pilot tone. Component C is derived from a 76kHz frequency, phase locked to the fourth harmonic of the carrier of component B, and modulated by a single-sideband technique with a sound signal. The lower sideband is used, and the subcarrier suppressed, so that component C consists only of modulation sideband frequencies between 76kHz and about 60kHz. Different key frequencies, or combinations of frequencies, are transmitted in component B according to the programme content of the sound in component C.

In the receiver, the sound signal in component A is recovered conventionally. The 76kHz subcarrier is regenerated by quadrupling the 19kHz pilot tone, and a product detector used to recover the sound signal in component C with high quality. Component B is monitored by a circuit which can be pre-set by the listener to respond to one or more key frequencies or frequency combinations. When such a frequency or combination is present, the audio circuitry of the receiver is switched to reproduce the sound from component C.

## Ultrasonic holography in medical diagnosis

Workers in the Medical Engineering Department of Surgery at the Children's Hospital of San Francisco have recently produced some extraordinarily fine ultrasonic halograms using an immersion scanning technique for visualizing some internal organs of the human body. The basic technique of using ultrasonic holography has been used for the past twelve years but most of the early results proved disappointing. Three dimensional images of internal structures made without subjecting the patient to painful or hazardous procedures are the dream of every diagnostician.

The technique of the new system, manufactured by Holosonics Inc. of Richland, Washington, U.S.A., differs from optical holography in that the interference wave pattern cannot be recorded on film. It is recorded instead by making the sound beams impinge on a fluid surface which is disturbed according to the sound intensity pattern. This surface pattern is detected by coherent light from a laser and the reflected beam used for optical image reconstruction.

The Holosonics instrument employs a five-inch quartz crystal with a fundamental frequency of 1MHz as the ultrasound generator. Harmonics bringing the operating frequency up to 3.5 or 7MHz are used. The limb or organ to be investigated is immersed in the fluid between the crystal and the acoustic lens system. A reference beam is provided by a similar transducer. The depth of focus obtained is about 1cm. Images are recorded on film or on a videotape system.

Operated in the pulsed mode, the average sound intensity is about 20mW $cm^{-2}$. With pulses of 100 microsecond duration at a repetition rate of 50Hz the peak intensity could exceed $4Wcm^{-2}$ which is questionably high if reproductive organs are allowed into the beam, as they would be for the examination of the uterus.

This system seems to have neared the ideals of acoustic holography and may well prove to be valuable not only to medicine but in other applications of non-destructive testing.

## Anti-skid control by micro-circuits

Two integrated circuits designed specifically for the automotive market have been announced by the Fairchild Camera and Instrument Corporation. Both are complex linear circuits developed over the past two years as "custom" circuits before being added to the standard product line. Typical applications include the control of anti-skid systems, fuel metering and the generation of either digital or analogue tachometer displays. Both are subsystems that will be used as components of larger automotive electronic systems.

The UA7350 includes a tachometer pulse generator, an operational amplifier and two comparators on a single chip, in a 16-pin dual-in-line package. The tachometer section produces fixed-width pulses at the zero crossings of a ground-referenced alternating current input signal.

The UA7351 is a triple operational amplifier, a general purpose circuit also specifically designed for automotive operation, with single 4- to 16-volt or dual 2- to 8-volt power supplies. The circuit contains three identical op amps on a single circuit chip in a 16-pin dual-in-line package.

## New interference regulations

New regulations controlling interference from the ignition systems of internal combustion engines* have recently been introduced to Parliament by Sir John Eden, Minister of Posts and Telecommunications. They extend the frequency range controlled by the present regulations in order to give greater protection to the whole range of frequencies now used by television. They have been made after consultation with the Minister's advisory committee on wireless interference from ignition systems and come into force on October 1.

The existing Wireless Telegraph (Control of Interference from Ignition Apparatus) Regulations made in 1952 require assemblers, importers and users of ignition systems forming part of combustion engines (other than in aircraft) to ensure that the field strengths of electro-magnetic energy radiated at frequencies between 40MHz and 70MHz do not exceed specified limits. These regulations will still apply to ignition apparatus assembled in engines before 1 October 1973.

The new regulations which extend the frequency range to 250MHz conform with the agreed international standards for radio interference suppression with which all vehicles manufactured on and after 1 October 1973, have to comply under the Motor Vehicles (Construction and Use) (Amendment) (No.4) Regulations 1972†.

*The Wireless Telegraphy (Control of Interference from Ignition Apparatus) Regulations 1973, SI No 1973/1217 published by HM Stationery Office.
†SI No 1972/1734 published by HMSO on behalf of the Department of the Environment.

## U.S. "TV Time" system

Time-of-day information can be broadcast to one millionth of a second accuracy by a new system developed by the U.S. National Bureau of Standards at the Boulder, Colorado laboratories. Equipment at the broadcast station and complementary decoding equipment on the TV receivers allow information to be encoded and decoded to provide information in caption form on the screen. The aim is to provide accurate information to scientific and commercial institutions which need precise time and frequency data. The signals can be used to automatically reset electric clocks after a power failure and can help to analyse power failures on a continent-wide basis.

The primary standard of frequency and time is the N.B.S. atomic clock system which provides a time display accurate to a few thousandths of a second with a possible accuracy to one millionth of a second using an optional high-accuracy decoder. A frequency reference at 1MHz, accurate to one part in $10^{11}$, is also available at the receiver.

## P.C.M. for the North

The B.B.C. has now completed a further stage in its p.c.m. sound distribution system, which will make it possible to start a full p.c.m. stereophonic service from the stations at Holme Moss and Belmont. These stations serve most of Lancashire, Yorkshire and Lincolnshire, and parts of the adjacent counties.

Test transmissions in stereo have begun from both stations but it may be necessary to revert to monophonic transmission on occasion, for essential engineering work. The new system will be used for Radio 1 (when that programme is transmitted on v.h.f.). Radio 2, Radio 3, and Radio 4, Radio 3 has been transmitted in stereo for some years, but it will be using the new p.c.m. system for the first time (See "News", Sept. 1972, page 411.)

## Minicomputer on a card

A minicomputer, the Naked Mini/LSI, contained on a 15 × 17 × 1in printed circuit board has been introduced by Computer Automation. Contained on the card are a 1.6-μs central processing unit (seven m.o.s. l.s.i. chips), memory storage and input/output logic interfaces, etc, making up a total weight of 4lb. The minicomputer is also available complete with chassis, control console, hexadecimal data-input keyboard and power supply, in which configuration it is known as the Alpha/LSI. Compared with Computer Automation's previous 16-bit minicomputers, their new machines cost half the price, occupy one-third the volume and offer functionally the same performance.

*Two geologists from the Polish Institute of Mining inspect three seismometers, with their attendant amplifier/modulators, which are part of a quantity of seismological recording equipment manufactured by Racal-Thermionic. The equipment has been adapted to accurately predict and locate potential "rock burst" activities — a mining phenomenon extremely dangerous to men and machinery underground.*

## Radio 4 in the South-West

The B.B.C. has recently been authorized by the Ministry of Posts and Telecommunications to install five low-power transmitters in the south-west of England. These will broadcast the medium-wave Radio 4 service, including the locally produced magazine programme, news and weather reports which are at present transmitted on v.h.f. only.

The locations of the first four stations, together with their proposed wavelengths and the service dates which it is hoped to achieve are as follows:

| | | | |
|---|---|---|---|
| Torquay | 351 meters, | 854kHz | Autumn 1973 |
| Barnstaple | 439 meters, | 683kHz | Autumn 1973 |
| Plymouth | 206 meters, | 1457kHz | Autumn 1973 |
| Redruth | 397 meters, | 755kHz | Spring 1974 |

The Barnstaple service will replace the present one on 434 metres; the others will be additional to the existing Radio 4 medium-wave services.

## TV deliveries in the U.K.

Deliveries of colour TV receivers to U.K. distributors have reached a total of 1,322,000 for the first half-year, a rise of 74% on the same period last year (761,000), according to the latest figures compiled by the British Radio Equipment Manufacturers' Association. Deliveries of monochrome sets for the first six months of this year were 765,000, a fall of 19% over 1972 (943,000 for the same period).

These are totals of U.K.-made and imported deliveries to the home market, including those to specialist rental and relay companies.

## Briefly

**The Sonex 1974** audio exhibition will move to the Post House Hotel, London Airport (Heathrow) and takes place from 29th to 31st March.

**The U.S. Postal Service** has issued a commemorative stamp for the 25th anniversary of the transistor — part of a series on the progress of electronics.

**A Wireless World Annual** is to be published for the first time later this year. Details will be announced shortly.

# Electronic Sound Synthesizer: Part 2

## Continuing the construction with descriptions of voltage control circuitry, reverberation and the exponential converter

*by T. Orr,* B.Sc., and D. W. Thomas,† Ph.D., M.I.E.R.E.*

The first part of this series of constructional articles (August issue) described the philosophy behind the design of the synthesizer and its capabilities as a musical or educational instrument. The series continues with constructional detail of the circuitry. Each basic modular unit is described in full, but the number of units employed can be varied to suit the constructor's needs.

### Sweep frequency oscillator

By driving $VCO_1$ with a ramp, generated by $VCO_2$ (both described last month), it is possible to produce a sweep frequency oscillator capable of covering the entire audio spectrum in one sweep (Fig. 14). If the swept sinewave output of $VCO_1$ is then fed into a network, the amplitude-frequency response of that network can be rapidly determined. A three decade sweep is available and the peak to peak amplitude is virtually constant. However, the sinewave generated by $VCO_1$ is by no means pure, having a harmonic content of between 3 and 4%. This limits the resolution to a rather modest value, but even so, a reasonable representation of the network's frequency response can be obtained. (It is particularly useful for directly observing the effect of tone controls in audio amplifiers.) To display the amplitude-frequency response, the ramp drives both the oscillator $VCO_1$, and an oscilloscope (in the $x$-direction), whilst the network response is displayed in the $y$-direction. The drive need not be a ramp; in fact any continuous function could be used.

### Voltage controlled oscillator, $VCO_3$

This oscillator produces a sequence of steps, the amplitude of the steps being individually controllable. The number of steps in the sequence can be varied up to a maximum of six (Fig. 15) and a series of pulses is also available (1 to 1 mark/space ratio) each being coincident with the leading edge of each step. The oscillator is voltage controlled and has a pair of summing inputs. The frequency-voltage relationship is exponential and extends from subsonic frequencies to above 20kHz, all in one range.

The oscillator, which consists of a voltage controlled astable[1] driving a binary counter, is shown in block diagram form in Fig. 16.

*Electronic Music Studios.
†University of Southampton.

*Fig. 14. Using $VCO_1$ and $VCO_2$ as a sweep frequency oscillator.*

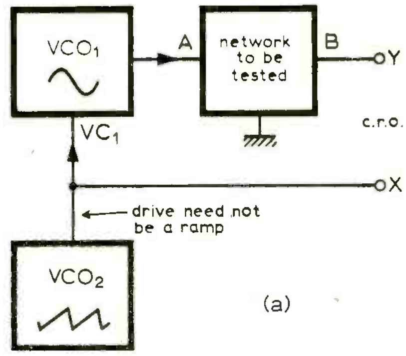
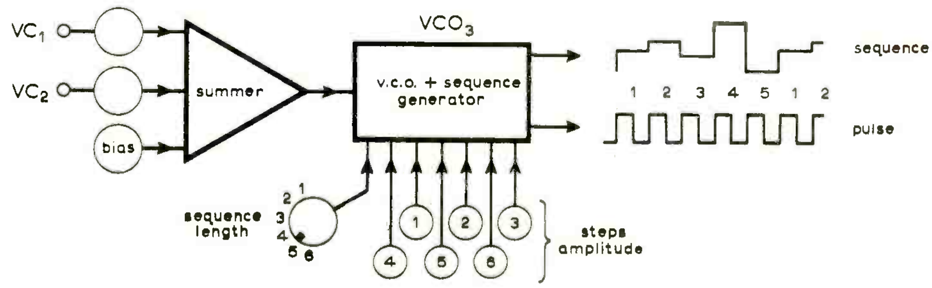



*Fig. 15. Functions provided by voltage controlled oscillator, $VCO_3$.*



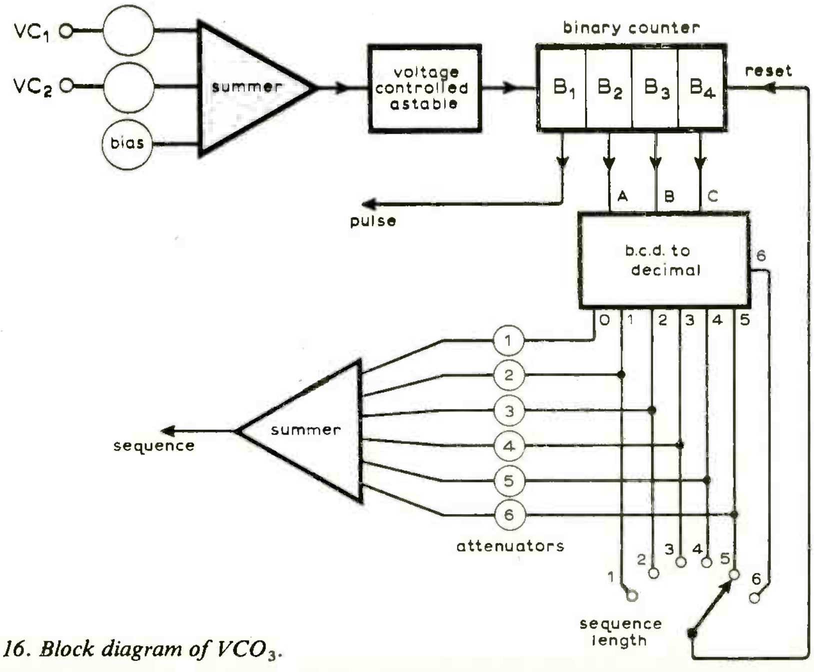




*Fig. 16. Block diagram of $VCO_3$.*

The b.c.d. output is decoded into decimal form, attenuated by pots 1 to 6 and then summed. The length of the resulting sequential output can be modified by selectively resetting the binary counter. The circuit diagram of $VCO_3$ is given in Fig. 17. Transistors $Tr_2$ and $Tr_3$ are voltage driven and provide a current drive to the astable. The result is an exponential current-voltage relationship and an exponential frequency-voltage response.

The useful range of the control voltage applied to $Tr_{2,3}$ is a few hundred millivolts, and must be generated relative to $+V_{cc}$. Preset $R_7$ is adjusted so that the clock frequency produced is approximately 20kHz with the bias set at maximum. Also, when the bias is set to a minimum, preset $R_{10}$ is adjusted so that the clock frequency is approximately 0.2Hz. Unfortunately, the effects of $R_7$ and $R_{10}$ are interdependent and hence they must be set up iteratively until convergence is achieved on the desired settings.

The logic section is self explanatory; however, the logic power supply must be decoupled with a 0.1$\mu$F capacitor. Note that this oscillator does not lend itself to construction on plug-in boards, as the edge connections required are exceptionally large.

### Voltage controlled amplifier, $VCA_{1,2}$

The heart of this unit which performs the function of amplitude modulation is a linear four quadrant multiplier, the device being an integrated circuit, SG1495D. This device operates from a +15V supply, and when used in the circuit shown in Fig. 18 can accept inputs of $\pm$5V. The frequency response is greater than that required. The output is taken between two load resistors and a differential amplifier ($IC_2$) is required to remove the common mode signal. Design of the multiplier and differential amplifier is very nearly the same as that given in the applications sheet for the SG1495D but some component values have been modified and lower tolerances are used. A scale factor of 0.1 is employed.

The multiplier accepts two inputs, X and Y, and generates an output that is linearly proportional to the product XY. The X input is the audio signal $VA_1$, and the Y input is the output of the control circuit. This circuit is a voltage summer with inputs of $VC_1$, $VC_2$ and a bias voltage. This arrangement is that of a "perfect" half wave rectifier, thus, when the sum of the control and bias signals goes negative, the output of $IC_3$ remains at 0V. Only when the sum is positive will an output (a control voltage) be produced. In this way, the control section has a threshold characteristic, this threshold occurring at 0V and being used as the reference level for zero output from the v.c.a. When long leads are used, parasitic oscillation may occur, but this can be suppressed by an $RC$ network ($C_1R_2$).

### Aligning the v.c.as

Four presets (Fig. 18) have to be aligned; these are $R_{20}$, $R_{21}$, $R_{14}$ and $R_8$. The first two are Y and X "offset adjust", the third is "gain" and the last is "output offset".

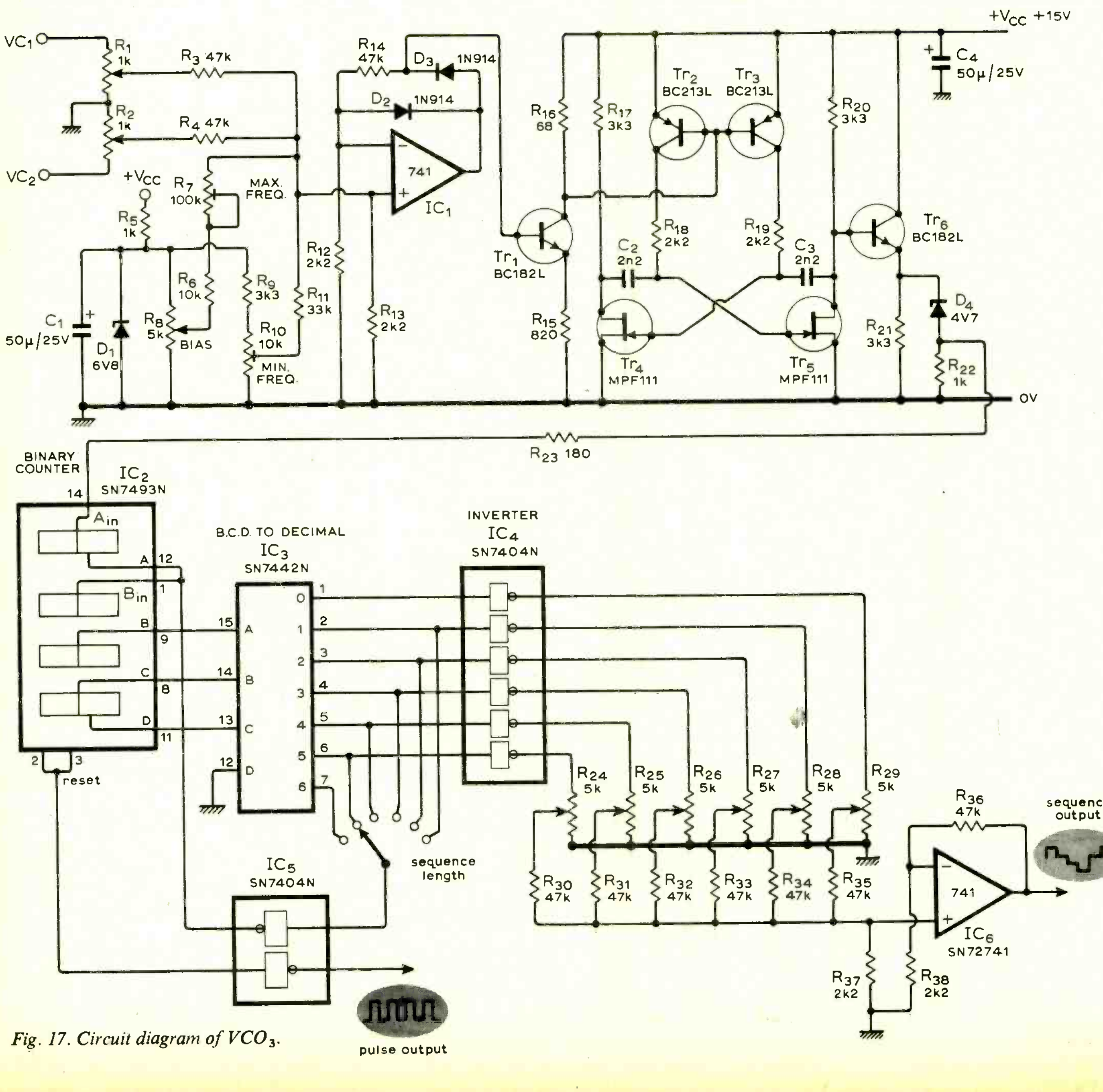



*Fig. 17. Circuit diagram of $VCO_3$.*

Set X and Y to 0V making sure that the bias ($R_{25}$) is set at its most negative setting. Monitor the output of $IC_2$ and adjust the output offset ($R_8$) until it is at zero potential.

Set X to +5V, but keep Y at 0V, and adjust $R_{20}$, the Y "offset adjust" until the output is again at zero potential.

Set Y to +5V, set X to 0V, and adjust $R_{21}$, the X "offset adjust", until the output is once more at zero potential.

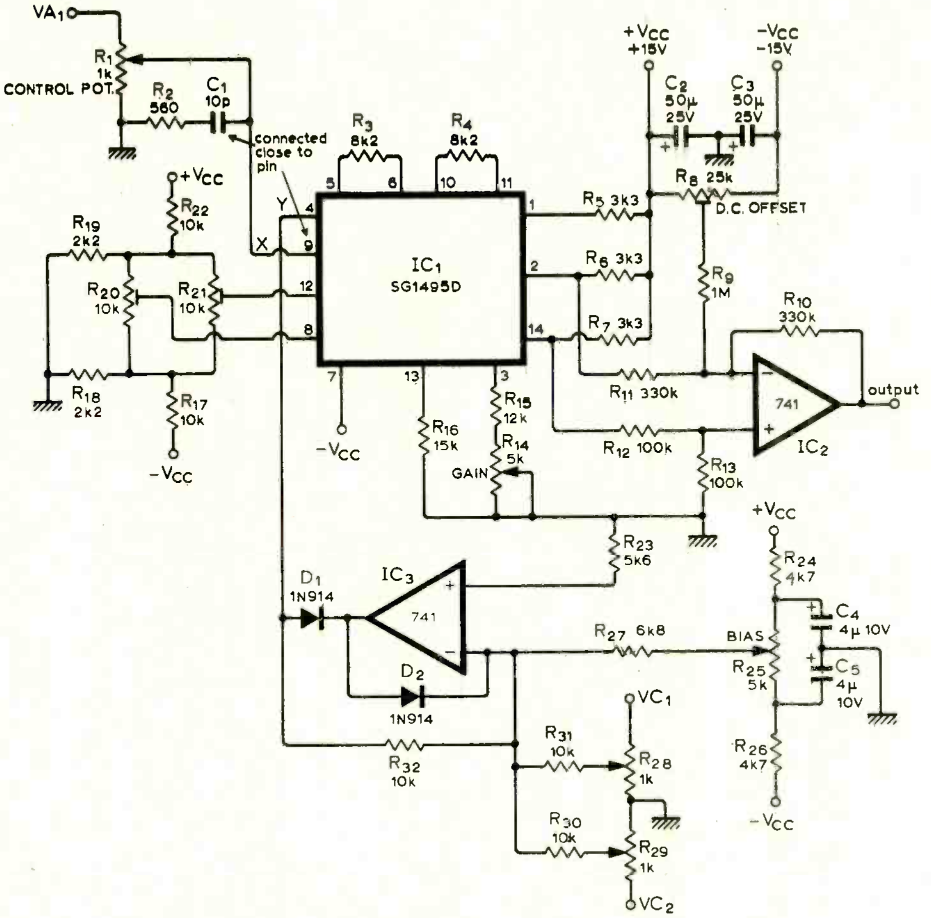



*Fig. 18. Circuit diagram of voltage controlled amplifier $VCA_{1,2}$.*

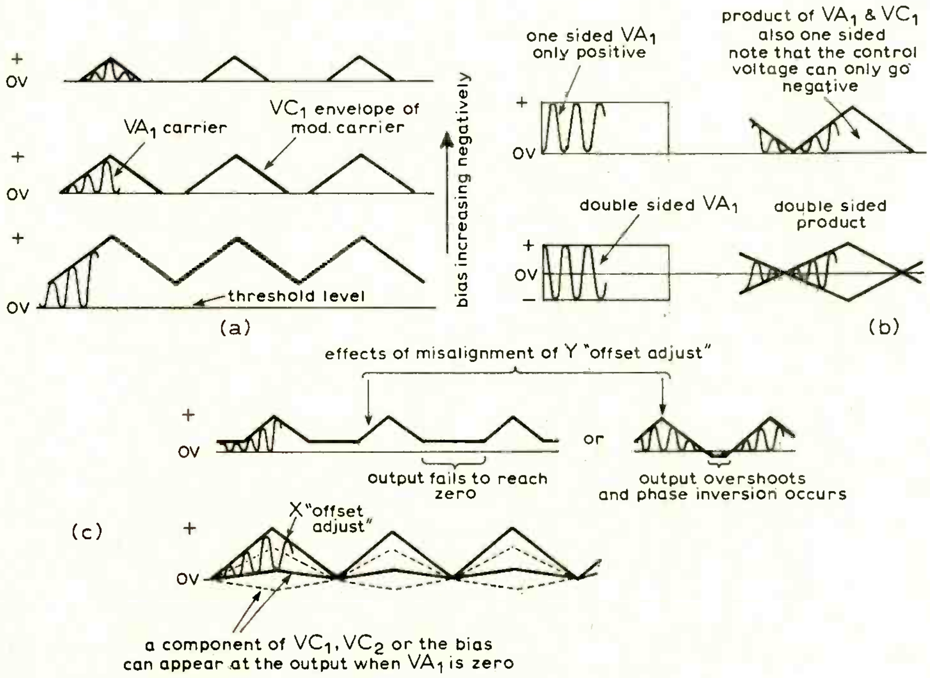



*Fig. 19. (a) Variable threshold effect in aligning the v.c.as. (b) Waveform envelopes from $VA_1$ and $VC_1$ products. (c) Effects of misaligning the Y "offset adjust". See text for full explanation.*

Now repeat the first step. The last preset to be adjusted is $R_{14}$, the gain control, which alters the scale factor of the generated output. The unit is now a functional v.c.a., and some amplitude modulation can be demonstrated. Also the audible and visible effect of varying the X and Y "offset adjust" can be observed.

Let $VA_1$ be a 1kHz sine wave and $VC_1$ be a 100Hz triangular wave. By varying the bias control, the product can be made to rise or fall above the reference level horizon (Fig. 19a).

If the sinewave and triangle are produced by $VCO_1$ and $VCO_2$, then the output will also be one-sided as both of these signals are one-sided (Fig. 19b). If however, the signal $VA_1$ is alternating, then a double sided output will be produced.

The effects of misalignment of the X and Y "offset adjust" can now be observed. For the Y "offset adjust" the result is that the output is non-zero when the control voltage reaches the threshold level. The output may never reach zero or may even pass through zero and become inverted (Fig. 19c). The dynamic range of the v.c.a. is thus severely limited by errors in the setting of the Y "offset adjust". Misalignment of the X "offset adjust", results in the unwanted components of $VC_1$, $VC_2$ and the bias appearing at the output, this being particularly disturbing when $VA_1$ is zero.

### Voltage controlled filter

The v.c.f. is a bandpass filter with presettable $Q$ factor and a variable (and voltage controllable) centre frequency. The circuit diagram of the v.c.f. is given in Fig. 20. The use of a multiplier makes the circuit appear rather complex; an alternative approach is to use f.e.t. modulators. The result would be a reduction in circuit complexity and cost, paid for at the expense of increased distortion and a loss of linearity of the centre frequency with respect to the control voltage.

The circuit operation is as follows. The sum of the bias and the input control voltage is squared and used to drive the multiplier. The transfer function of the square law generator is given in Fig. 21, transistor $Tr_2$ being designed to saturate when its collector reaches a potential of −5V. The multiplier is similar to $VCA_1$ and $VCA_2$, but in this case forms part of the main loop with the two integrators. Integrator gains of $3.3\times10^4$ are used and the first integrator is limited by zener diodes $D_{10}$ and $D_{11}$. If the output swing of this integrator were allowed its full range of movement, the maximum input of the multiplier would be exceeded, causing the loop to become unstable and then "hung-up". The $Q$ factor can be modified by adjusting $R_{22}$ and theoretically when the wiper of this pot is at 0V there is no damping term, and the loop becomes unstable. This situation may or may not occur, it being dependent on component imperfections and the way in which the circuit is constructed.

It was decided that this filter should not become oscillatory at high $Q$ factor settings. Thus to eliminate this possible state, $R_{23}$ has been included, the value of which is chosen to make the loop non-oscillatory

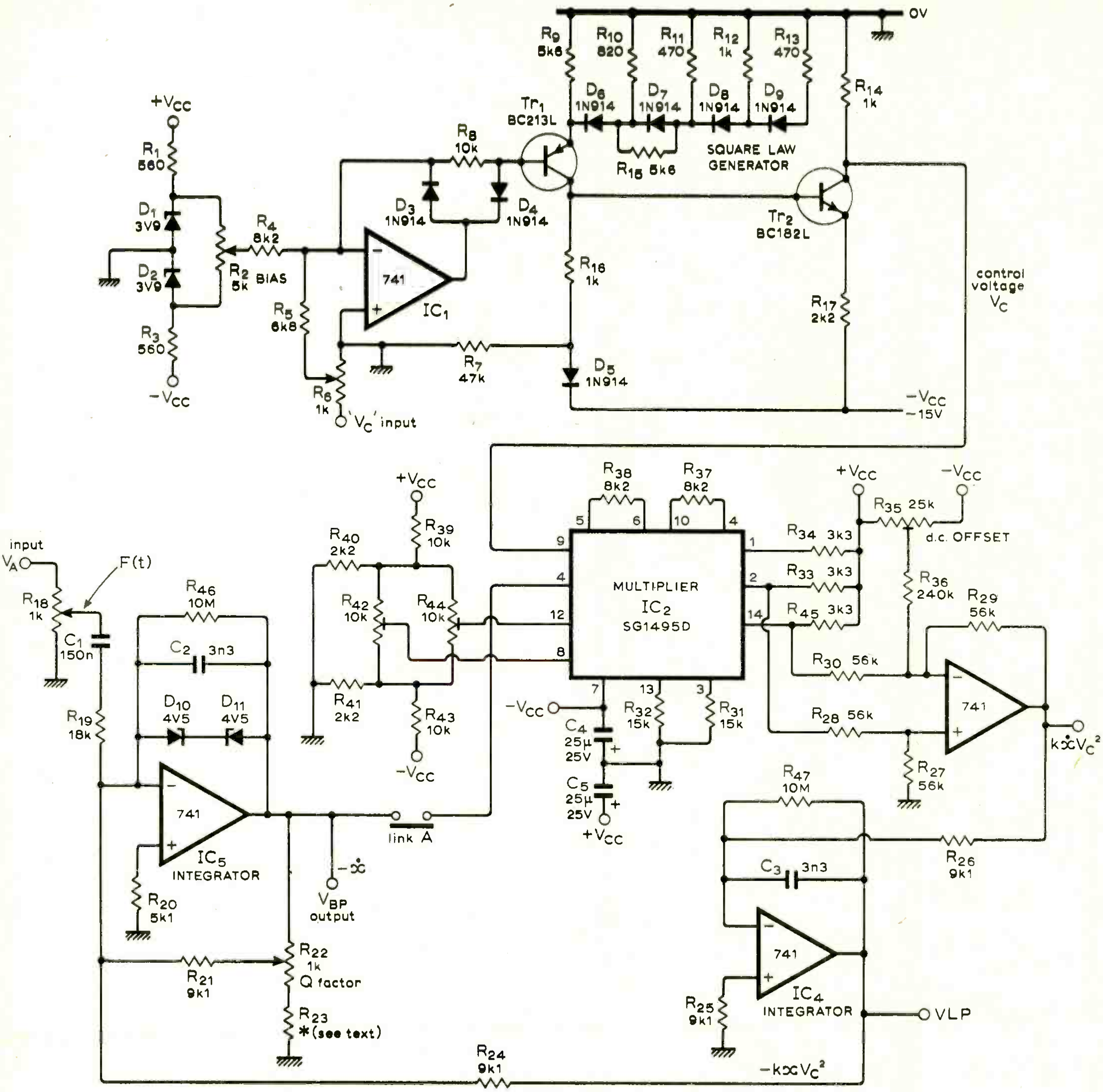



*Fig. 20. Circuit of the voltage controlled filter.*

throughout its ranges. The v.c.f. can be modified externally so that it forms a low distortion oscillator, but this will be described later. Other synthesizers tend to prefer the use of low pass v.c.fs, and this is easily achieved by taking the output from $IC_4$, the low pass output. In fact there is no reason why the bandpass and the low-pass outputs should not be simultaneously available.

## Filter alignment

Careful adjustments of presets $R_{42}$, $R_{44}$ and $R_{35}$ are required, because the multiplier is part of a loop that can easily become unstable, particularly at low values of gain.

Break link A, Fig. 20, and align the multiplier using the method described for $VCA_1$ and $VCA_2$. Note that there is no "gain preset" to adjust. Replace link A and monitor the output of $IC_5$. This potential may need to be zeroed by adjusting $R_{35}$, this offset being particularly large when the bias control is set at minimum. If the multiplier has been carefully aligned to give a maximum dynamic range, then a range in centre frequency of about one octave can be expected. Note that the multiplier's gain should not quite reach zero or (even worse) pass through it and hence change sign, as both of these states are unstable.

The v.c.f. is now functional and can be used to perform a variety of operations. The more common uses are to filter inputs such as white noise, producing various effects similar to wind, rain, jet engines etc.

The v.c.f. can be used as a low distortion oscillator (Fig. 22a). The $Q$ factor and the bias are set at maximum and the control pot $R_{18}$ (Fig. 20) is increased so that the filter

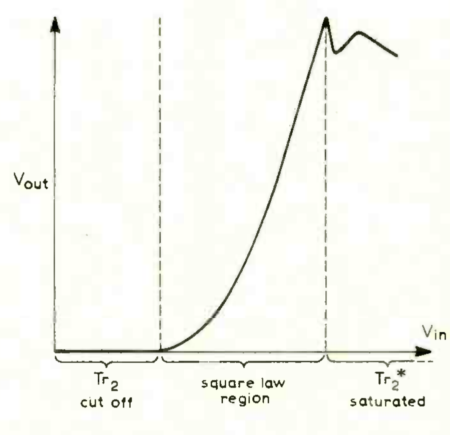



*Fig. 21. Transfer function of the square law generator in Fig. 20.*

just oscillates. The v.c.f. can now be swept throughout its range, producing a sinewave of virtually constant amplitude and of variable frequency (a 9.5 to 1 range was obtained). There is a 90-degree phase difference between the low-pass and band-pass output, sine and cosine waveforms being simultaneously available.

The v.c.f. can also be used as a notch filter (Fig. 22b). To set up the mixer, use a sine wave input and set the v.c.f. to the same frequency, with the $Q$ factor at maximum. By varying pots $VA_1$ and $VA_2$, the input and the bandpass output can be made to cancel out. The "notch" can then be swept throughout the v.c.f's range. This technique can be used to examine the harmonic content of any signal that lies within the frequency range of the v.c.f.

The v.c.f. is also useable as a spectrum analyser, measuring energy per hertz versus frequency (Fig. 22c). However, this is no more than a demonstration piece, due to the narrow range. Also, the sweep time must be rather long if a "high" resolution (i.e. high $Q$ factor) is required, and the constant bandwidth makes interpretation of results difficult.

### Audio mixer and summer/inverter

The audio mixer is a three channel virtual-earth mixer, each channel having its own attenuator and being a.c. coupled. A master volume control determines the overall signal level at the output (Fig. 23).

Also, two direct coupled virtual-earth mixers are provided (Fig. 24). These both have three inputs, two having a fixed gain of −1 and one of −10, and are used for

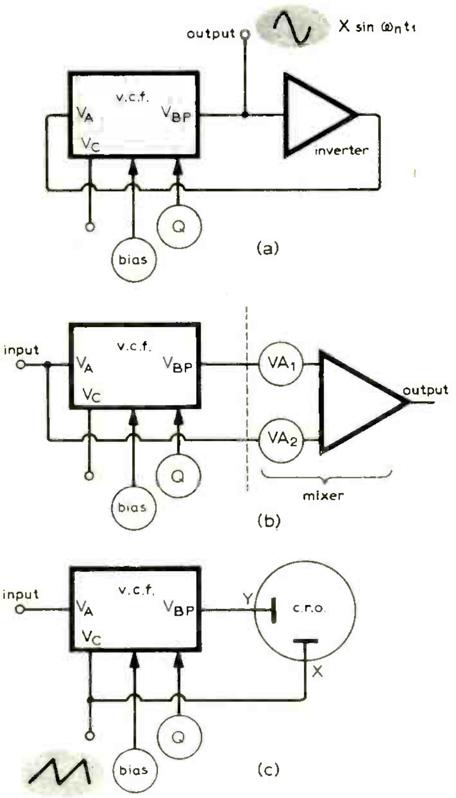



*Fig. 22. Using the voltage controlled filter as (a) a low distortion oscillator (b) a notch filter and (c) a spectrum analyzer.*

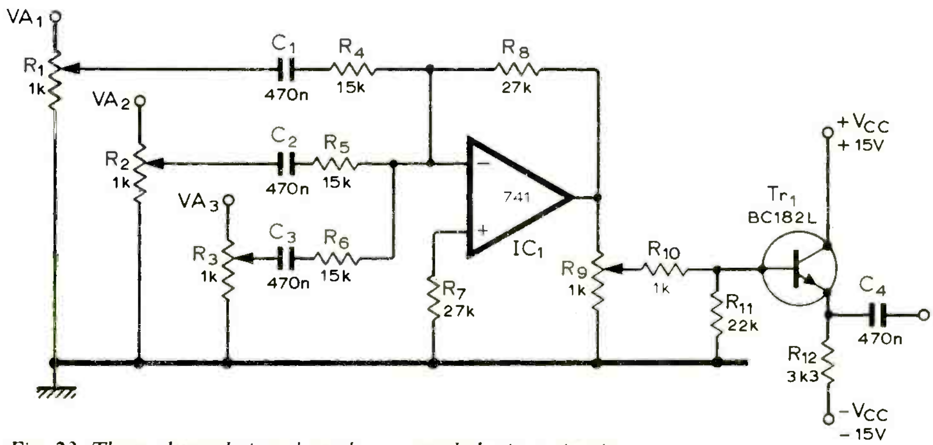



*Fig. 23. Three-channel virtual-earth a.c. coupled mixer circuit.*

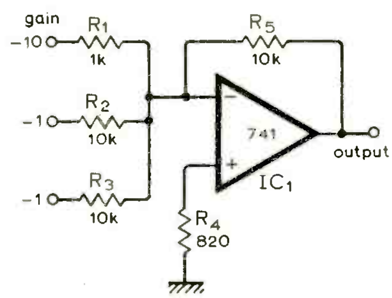



*Fig. 24. Direct coupled virtual-earth mixer.*

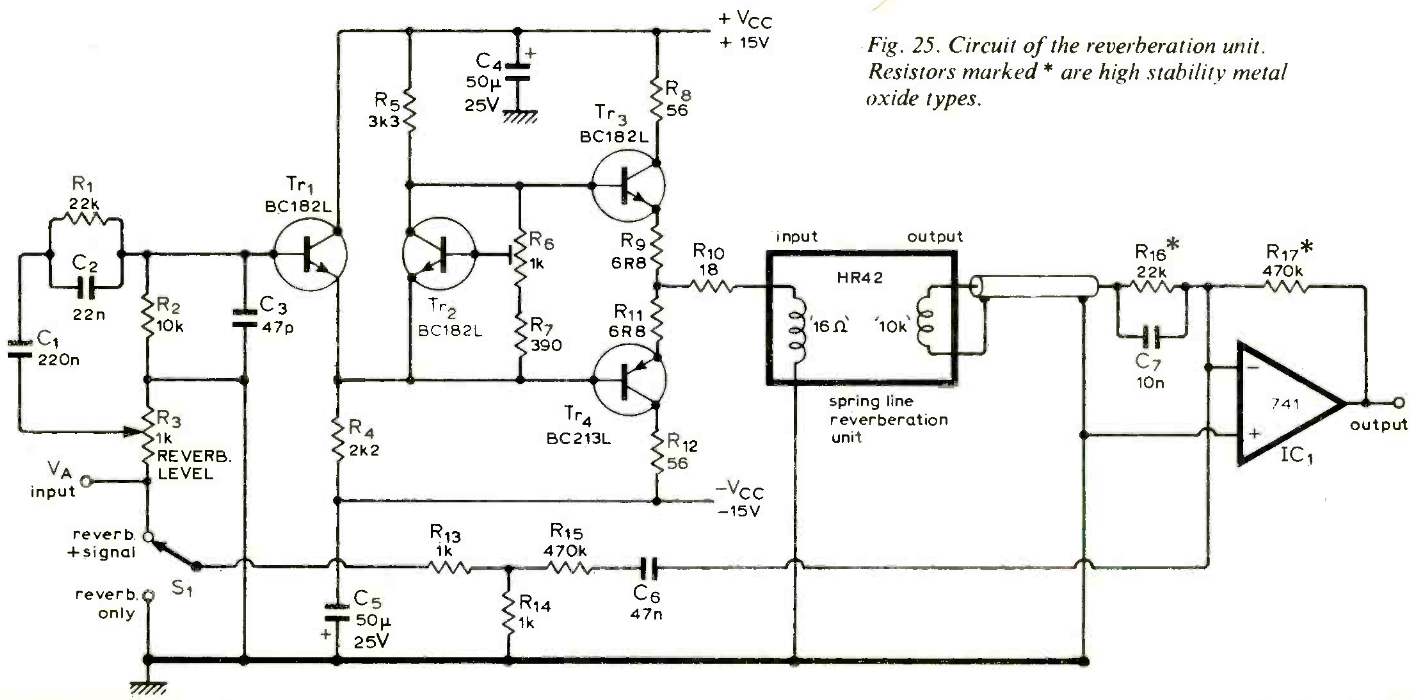



*Fig. 25. Circuit of the reverberation unit. Resistors marked * are high stability metal oxide types.*

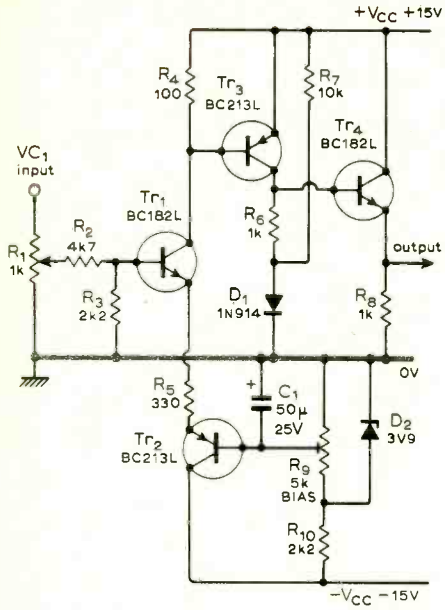



*Fig. 26. Circuit of the exponential converter. Two converters are included in the synthesizer.*

signal processing, such as inversion, summing or amplification.

### Reverberation unit

The reverberation unit consists basically of three sections; the driver, the springline reverberation unit and the equalised pickup amplifier (Fig. 25). The springline reverberation unit used was the "H242" obtainable from Henry's Radio. This unit is moderately inexpensive, but suffers from a loss of high frequency reverberation, dropping considerably at about 4kHz. However, a useful response can be obtained—enough in fact for this unit to be used in one of the commercially available synthesizers.

By operating switch $S_1$, a choice of the input signal plus reverberation, or just reverberation is available. Thus the reverberation can be separately controlled, by using a v.c.a. and/or a v.c.f., as well as being manually controllable ($R_3$). To reduce any microphonic effects, the HR42 unit should be mounted on a pair of rubber pillars.

### Exponential converter

This unit has an exponential transfer function of the form,

$$V_{out} = \exp(V_{in} + \text{constant})$$

The base-emitter junction of transistor $Tr_3$, Fig. 26, is voltage driven, the collector current being monitored. The relationship between $V_{BE}$ and $I_C$ is very nearly exponential, modified by the fact that the voltage drive is imperfect and the value of $V_{CE}$ ($Tr_3$) is changing. The suitable working range for the base emitter voltage of $Tr_3$ is from 0.5V to about 0.7V, a width of only 200mV. This requires that $Tr_3$ is biased to a $V_{BE}$ of about 0.5V and that the control voltage drive is suitably attenuated, the bias being preset by adjusting $R_9$. As two exponential converters are included in the synthesizer, both should be adjusted so that their responses are matched.

The need for an exponential transfer function is twofold. One, the subjective response to volume can be loosely described as "logarithmic". And two, the subjective response to a change in frequency is governed by the ratio of the two frequencies. Thus, frequency generation should be an exponential function of the control signal, if the control, from say a set of keyboards, is to be considered musically useful.

The construction of the synthesizer will be completed with a description of the sample and hold function, noise sources, waveform generator and power supply. All the synthesizer functions will then be linked via the patch panel, keyboards and joystick control. Details of i.c. pin connections will be given and also examples of the synthesizer's use.

### Correction

In Fig. 13, a resistor $R_{10}$ of value 1kΩ should be inserted between the +15V supply and zener $D_3$.

*(To be concluded)*

**Reference**

1. D. T. Smith, "Multivibrators with Seven-decade Range in Period", *Wireless World*, February 1972, pp. 85–86.

# Announcements

**"Sound Studios and Recording"** and **"Broadcast Sound Reproduction"** are two courses to be run during the Autumn and Spring terms 1973-74 at the Polytechnic of North London, Department of Electronic and Communications Engineering, Holloway Road, London N7 8DB.

The University of London, Department of Extra-Mural Studies is to hold a course of 22 meetings plus four visits on **"Hi-Fi and the Science of Sound"** at Callowland Adult Education Centre, Watford on Thursdays, 7.15 p.m.-9.15 p.m., beginning 11th October.

Information on part-time **courses in electronics** — including an R.A.E. course — at Plymouth College of Further Education can be obtained from E.H. Farrar, Head of the Department of Electrical Engineering, College of Further Education, Keyham Annexe, Keyham Road, Devonport, Plymouth, Devon.

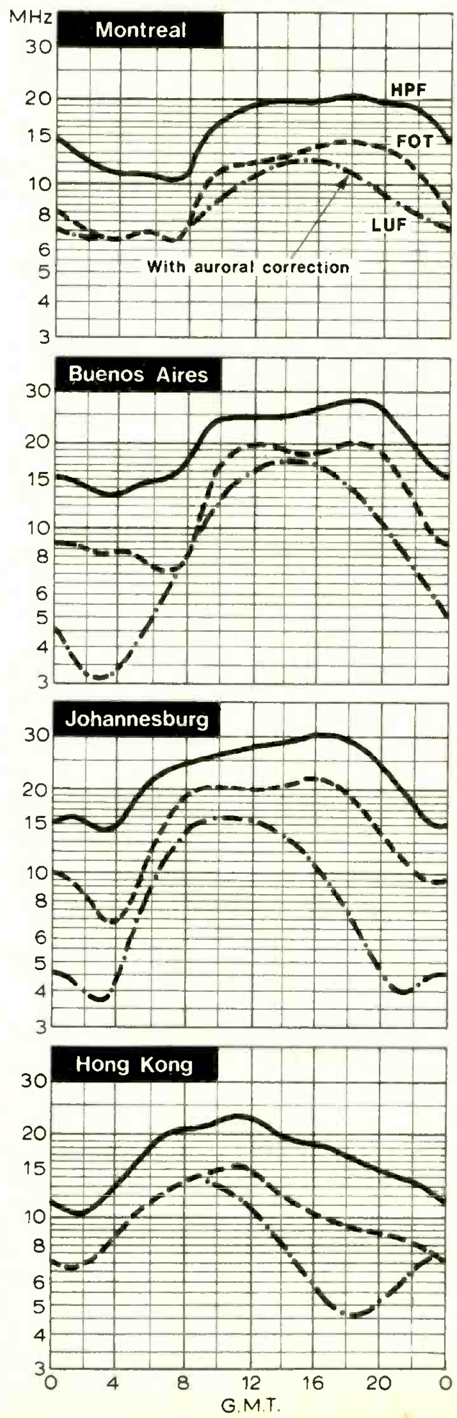
Surrey Electronics, 24 The High Street, Merstham, Redhill RH1 3EA are producing a glass fibre p.c. board for M. Hartley Jones' **"Frequency Shifter for Howl Reduction"** circuit published in the July issue. The board is 90 × 140mm with a gold plated edge connector to mate with a 12-way 0.15in socket.

A course of nine Tuesday evening lectures on the **"Engineering of High Fidelity Sound Systems"** will be given from 6.30 p.m. to 8.30 p.m. at Cambridge College of Arts and Technology, Department of Engineering and Building, Collier Road, Cambridge CB1 2AJ commencing on 9th October. Information is also available on an R.A.E. course and morse practice evening also commencing in October.

# H.F. Predictions for September

Seasonal changes will result in generally improved conditions in propagation. Long periods of subnormal days are unlikely. Ionospheric conditions are more favourable for the North Atlantic path and trans-equator-routes should be consistently workable above 20 MHz.

The period of the last sunspot cycle corresponding to current conditions was 1962. The solar index from then on did not rise above the present value of 25 until the beginning of 1966; by the end of 1966 it had risen above 60. The trough of sunspot minimum now upon us can therefore be expected to last until 1977.



# Circards — 9

# Optoelectronics: devices and applications

## Twinkle twinkle little led, how I wonder if you're dead

*by J. Carruthers, J. H. Evans, J. Kinsler & P. Williams**

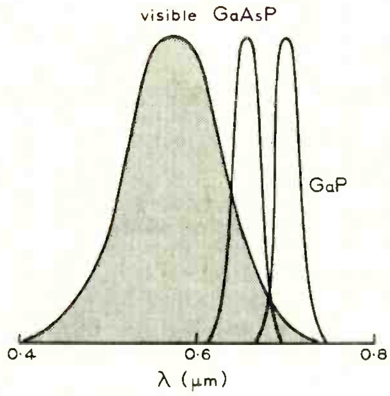
Three aspects of the link between light and electronic circuitry are considered in this article: detection and measurement of light, generation of light from an electrically operated source, and use of light as an intermediary in some electronic process. Of the wide array of optoelectronic devices available a small number cover a wide range of requirements. More specialized components, such as semiconductor lasers, photomultipliers, must be left to a later series.

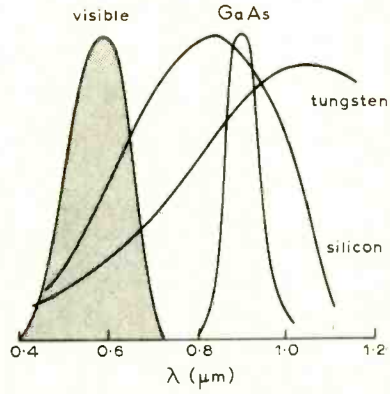
The electronics industry is seeing a production and pricing pattern in one family of optoelectronic devices reminiscent of the t.t.l. war at its fiercest. Light-emitting diodes have changed from an r & d novelty to a consumer component with great rapidity and are already falling to a price level comparable with the transistors used to drive them. They will replace filament and neon lamps for a wide variety of applications and it is on their characteristics that this series concentrates as far as light generation is concerned.

Light-emitting diodes are p-n junctions governed by the same rules as silicon diodes. The choice of materials is devided by the spectrum of light required while the efficiency can depend critically on doping levels. The most common materials are gallium arsenide and gallium phosphide (and other compounds) (Figs 1 & 2) with a current requirement of 5 to 50mA for normal brightness. The resulting p.d. is in the range 1 to 2V (Fig. 3) making the diodes compatible with both linear and digital circuits. Relative intensity of the lamp is an almost linear function of current over a wide range of currents (Fig. 4) falling at higher temperatures.

Response of the human eye is greatest in the yellow/green region of the spectrum, and the gallium arsenide-phosphide devices (Fig. 1) — which emitters peak in the red — appear less bright than otherwise comparable-efficiency yellow diodes. Nonetheless, economies of scale dictate the use of the lower-cost red l.e.ds for most applications.

Emission in other parts of the electromagnetic spectrum is possible with suitable materials including the highly specialized semiconductor lasers with a very narrow spectral response. Pulsed operation with low duty-cycle high-current pulses gives the highest efficiency with such devices, and they find application in optical communication systems.




*Figs. 1 & 2. Materials used in light-emitting diodes are chosen to give the desired colour. Although GaAsP diodes are of compararable efficiency to GaP diodes, they appear brighter because eye response is greater in that region (Fig. 1, left).*

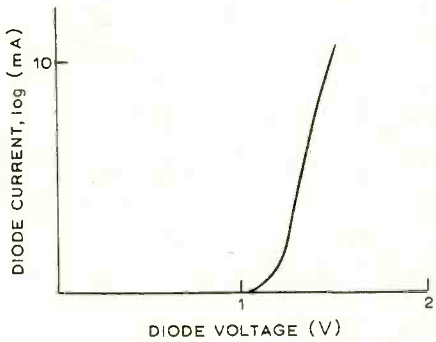



*Fig. 3. Light-emitting diodes have a p.d. of 1 to 2V for normal brightness levels, making them compatible with both linear and digital circuits.*

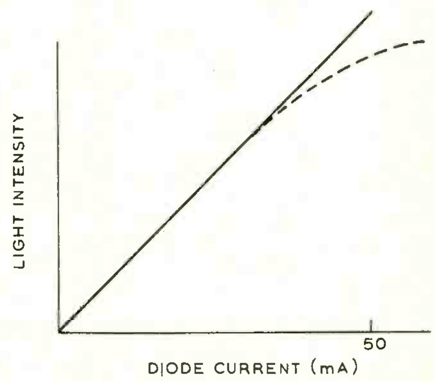
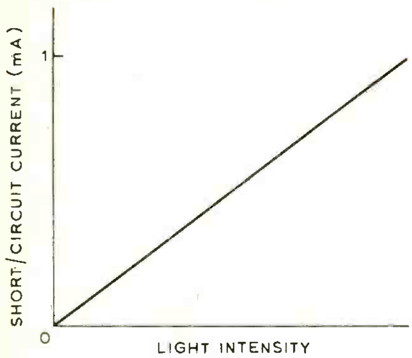


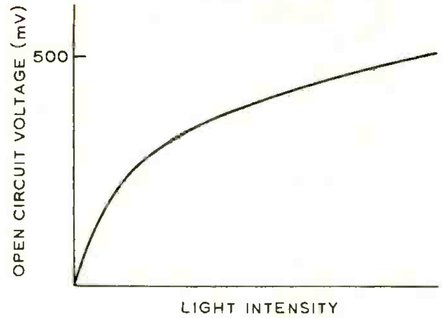

*Fig. 4. Lamp intensity is a linear function of current, except at higher temperatures (broken line).*

Solid-state light-sensitive devices are based either on p-n junctions (photodiode, photovoltaic cell, phototransistors) or polycrystalline materials (CdS photoconductive cells). Light falling on a p-n junction if of short enough wavelength generates hole-electron pairs. Current flows if the p-n junction is short-circuited (Fig. 5) or connected to a low-resistance load; current is proportional to the intensity of light falling on the junction, and the terminal p.d. for a silicon diode may be up to about 0.5V (Fig. 6).

A specialized form of photodiode, the photovoltaic cell, is used as a power source. Selenium, or more commonly now silicon, is the material used and the cells are arranged to have a high surface area to maximize their light catchment. Although having non-linear characteristics, the simple maximum-power-transfer theorem gives a first order answer for the optimum load (Fig. 7) i.e. that load which maximizes the output power is

*All with Paisley College of Technology.




*Figs. 5 & 6. In light-sensitive devices based on a p-n junction, current is a linear function of light intensity falling on the junction (Fig. 5, left). Open-circuit voltage can be as high as 0.5V with silicon photodiodes (Fig. 6, right).*

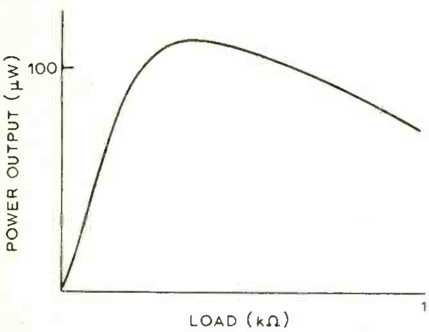



*Fig. 7. For selenium or silicon photo voltaic diodes maximum power is delivered for a load given by open-circuit voltage divided by short-circuit current.*

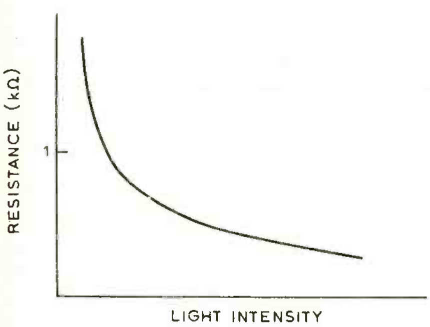



*Fig. 8. Photoconductive cells using cadmium sulphide normally have a non-linear light intensity solidus current characteristic although the voltage-current curve is linear.*

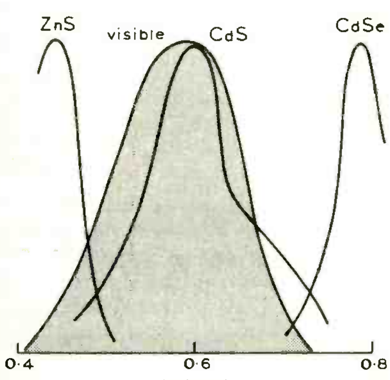



*Fig. 9. Because the spectral response of cadmium sulphide cells matches eye response they are widely used in photographic applications.*

given by $R_{opt} = V_{oc}/I_{sc}$. The theorem applies to linear systems but gives reasonable results for some non-linearity.

Further increase in load resistance or illumination makes for little extra p.d. as it becomes comparable with the p-n junction barrier potential. In a phototransistor the collector-base junction is illuminated and the transistor amplifies the resulting current. Currents of 10mA and more are possible but the speed of response is slower than for the diode alone when reverse biased. This latter mode is the fastest with a separate d.c. supply providing a high field to sweep the carriers out of the junction. The limiting effect on speed of response is often the *RC* time constant of the external circuit particularly as the currents are low, forcing the use of large resistors where large voltage swings are needed. Any voltage swing up to the supply voltage may be obtained provided that the supply voltage does not exceed the diode reverse-breakdown voltage.

Any other semiconductor device or circuit using a p-n junction may in principle be made into an optoelectronic device with suitable packaging. Thus photothyristors can be obtained which are fired by an optical pulse, though they are presently restricted to relatively low-current applications e.g. for firing a higher power thyristor. In this case the photothyristor needs to have high voltage breakdown characteristics but can be a low-power device supplying pulses of a few tens of mA to the power device.

Photo-Darlingtons and other transistor combinations are equally feasible where higher output currents are desired in linear circuits, but in many cases it is equally simple to combine a photodiode or phototransistor with other conventional transistors. M.o.s. devices are very useful in optoelectronic circuits, with the threshold voltage varied by the light intensity. By adapting the m.o.s. processes, complex circuits have been recently produced by i.c. manufacturers, to provide outputs capable of driving small relays and switching at preselected light intensity.

Cadmium sulphide photoconductive cells have a very high resistance in the absence of light, with the resistance falling rapidly with increasing light intensity (Fig 8). At all light intensities the device has a linear *V/I* characteristic, and for some devices the variation of conductance with light is itself almost linear. As the spectral response of CdS cells closely matches that of the human eye (Fig 9), they are used in photographic equipment. These cells have to be used with some external power supply, a.c. or d.c., as they do not generate any power. The advantage is that the power controlled in the load can be large enough to operate a wide range of lamps and relays.

A powerful tool for designers made possible by recent development is the photon coupler. This is typically an 8-pin dual-in-line package containing a light-emitting-diode tightly coupled, optically, to a silicon phototransistor. There is no electrical connection and breakdown voltages between the two sections of several kilovolts have been achieved. Similarly the capacitance coupling is small, and these devices are ideal for transmitting signals between circuits where direct electrical connection is impossible or inadvisable. Examples of such situations include firing of thyristors from grounded source and coupling between digital systems where ground noise is a problem.

Optoelectronics has passed the healthy infant stage and is developing into a mature branch of engineering where the choice is wide enough to encourage all designers to extend their skills.

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Subsequent issues will cover micropower circuits, logic gate circuits, wideband amplifiers, alarm circuits, digital counters, pulse modulators. Introductory articles in *Wireless World* indicate availability of Circards, which are normally ready for despatch on the 1st of the month, and the Circard concept was outlined in the October issue, pages 469/70.

# Industrial Electronics

## 5. Weighing systems

*by Richard Graham*

Having discussed the reasons for the development of electronic weighing and looked at load cells in broad outline (July issue, p.353), one is now in a position to examine complete systems, with their benefits and advantages over mechanical weighing equipment.

First, though, there is one more type of weighing transducer which should be mentioned — the class of cell employing the linear variable differential transformer as its measuring element. This device, which is exemplified by the Hunting Engineering weigh cell shown in Fig. 1, is used chiefly for low weights (milligrammes to a few kilogrammes) and, especially when temperature-compensated, is extremely accurate and stable. High-speed check-weighing is a typical application. The sketch shows a load-carrying platform, which moves vertically against a precision, temperature-compensated spring, being constrained to vertical movement by two flexural pivot arms of specially developed, temperature-stable, spring steel. Moving with the platform assembly is the l.v.d.t. armature, the coils remaining stationary. A dash-pot (not shown) prevents oscillation. The output of the cell is a.c., but precision rectifier units are obtainable to fit inside the cell and the input to the l.v.d.t. is provided by a highly stable high-frequency oscillator.

The output signal provided by most strain-gauge load cells is of the order of 2mV per volt applied and, depending on the manner in which multiple cells are connected together, the output provided to the indicating and processing circuitry is usually around 5-15mV, a.c. or d.c. Alternating signals have been the usual type, but many firms are now tending to use a direct-voltage input to the cells, preferring to deal with drifts in the electronics rather than with cross-talk and quadrature signals in a.c.-fed systems.

### Display

The type of instrumentation chosen depends to some extent on the display method preferred. Two schools of thought exist on this matter of readout: the protagonists of large dial displays with pointers, and the digital faction. Both methods of weight display have strong points in their favour, and each has its own most appropriate sphere of activity, in common with the displays of other types of measuring equipment. Those in favour of digital readout point out its lack of ambiguity and ease of comprehension, but it must be admitted that this obtains only when the reading is static. On the other hand, the proponents of pointers on dials assert that the information can be assimilated more easily and, in some cases, even without the need to actually read the numbers — the position, or angle, of the pointer giving an adequate indication. If a hopper or vat is filling or emptying, the pointer will follow and the instantaneous weight can be seen. In this situation a digital display would be uncomfortable, to say the least. It is perhaps true to say, however, that a digital display is more compatible with complete systems which must interface with peripheral equipment such as printers, batching controllers and computing devices. A typical arrangement would be as shown in Fig. 2.

**Dial indicator.** A typical dial indicator is shown diagrammatically in Fig. 3, where it shows the weight borne by four load cells. The outputs of the cells are combined and amplified to a workable level, and

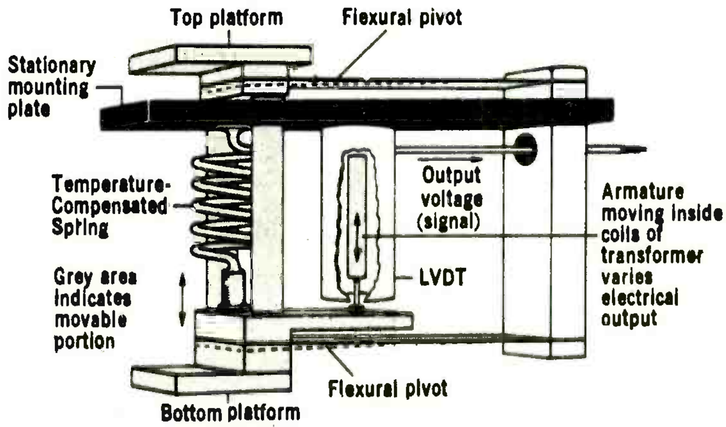



*Fig. 1. The Hunting l.v.d.t. weighing cell.*

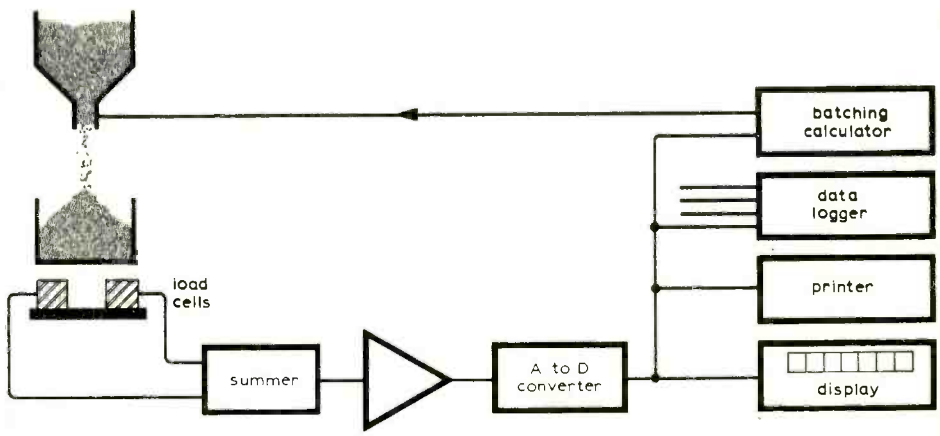



*Fig. 2. A possible configuration of a complete weighing system with ancillary recording and batching equipment. The batching controller detects coincidence between the digital output of the display unit and a preset number, and controls the hopper output.*

form one input to a comparator. The comparator output drives a motor which rotates the pointer over the dial. On the same shaft is a high-quality potentiometer which rotates with the pointer and which drives the other input of the comparator with the voltage on its wiper. As the amplified signal from the load cells at the comparator varies, the motor, pointer and potentiometer shaft rotate until the voltage at the other input to the comparator equals that from the load cells. The pointer now indicates the weight. In practice problems occur with hunting, as in any servo system, and much of the electronics is concerned with achieving adequate sensitivity while retaining stability.

**Digital indication.** In essence, the electronic design of a digital weight indicator is identical with that of a digital voltmeter and is simply concerned with analogue-to-digital conversion. Several different methods of doing this exist, and have been adequately described many times. Dual-ramp integrators, ladder networks and voltage-to-frequency converters are used, and the availability of integrated a-to-d converters must have a significant effect on this type of equipment. One of the advantages of this digital type of display is that the signal itself is now digitized and is available for transmission to other equipment.

## Applications

**Containers.** Perhaps the most common application of load-cell measurement is the weighing of the contents of large silos or vats. In place of levers and knife-edges (and imagine the problems associated with mounting a 500-ton silo in such a manner) it is only necessary to sit the container on three or four load cells arranged round its perimeter, and the rest is electronics. It is, of course, necessary to ensure that the load applied to the cells is truly vertical and that side loads due to thermal expansion are eliminated by "floating" mountings, and for this reason it is sometimes found necessary to "hang" the container from tension cells rather than resting it on the compression type. Mechanical connections to the container must be arranged to exert the minimum resistance to load.

**Weighbridges.** Anyone who has seen below the load platform of a large mechanical weighbridge will readily understand the attraction of load cells for this application. The elimination or reduction in depth of the pit and the replacement of immoderately dimensioned levers with insignificant load-cells is not the only attraction however; the signal from the cells is easily transmitted to remote displays without the use of further levers, and a digitized signal is already in a form for input to other equipment for process control or data-collection.

**Cranes.** The mechanical way of weighing the load suspended from the hook of a crane is to suspend a complete weighing machine "in series" with the load, complete with its dial. Electronically, the method is to interpose a load cell somewhere between the gantry and the load (the exact position varies with manufacturer) and to lead the signal away to a fixed control and display console. The loads suspended from crane hooks are, in some cases, highly inimical to delicate mechanisms; molten metal, for instance, exudes fumes and quantities of heat: load cells are readily rendered relatively immune to this kind of treatment. It is also possible to arrange for the cell to provide an alarm signal which will indicate overload.

**Belt-weighing.** This is an application which has caused a certain amount of hair-tearing and teeth-gnashing until quite recently, and the accuracies obtained are still not much better than a claimed 1%. The essential information delivered by a belt weigher is the rate of flow of material over the belt (weight of a given amount × speed) and the total amount conveyed.

In one example of belt weigher, designed by Philips, the belt produces a train of pulses, the frequency of which corresponds to the belt speed, by means of a slotted disc moving in the inductive feedback loop of an oscillator. The pulses are converted into a varying voltage level in a frequency discriminator, the level becoming the input to the load cells, which bear the weight of a fixed length of belt. The cell output, therefore, is representative of the speed of flow multiplied by the weight (rate of flow). This signal is amplified to drive an indicator and is also applied to a frequency-to-voltage converter, the output of which (another train of pulses) is counted and totalized, thereby providing the "total" output.

A design was produced some time ago by Richard Sutcliffe Ltd, using l.v.d.ts as weight transducers, mounted on spring cantilevers which bear the load and which deflect linearly. A tacho-generator driven by the belt supplies the primary drive for the l.v.d.ts, the output of which is, again, speed times weight. This is indicated, as before, and gives rate of flow information. Integration to obtain "total" readout is performed by a watt-hour type of meter driven by the rate output, which has a perforated disc, with lamp and photocell mounted on its shaft. The pulses produced by the turning of the disc are counted to give the total.

These four applications probably account for the majority of load-cell weighing equipment in use, although many are in use in diverse other fields of activity. In medicine, for instance, it is used to measure minute variations in the weight of patients undergoing kidney dialysis. In this application, small variations are imposed on a static weight which is many times larger (the weight of the bed and patient), a constraint which requires considerable stability and resolution in the electronics as only a a small portion of the transducer output can be used.

In conclusion, it can be said that load-cell weighing offers convenience in the design, construction and maintenance of large systems, ease of interfacing with data-handling equipment and a ready means of obtaining remote or multiple displays. Cost saving becomes apparent in larger systems, but even in the smaller systems, cheapness is sometimes traded for the other attractions.

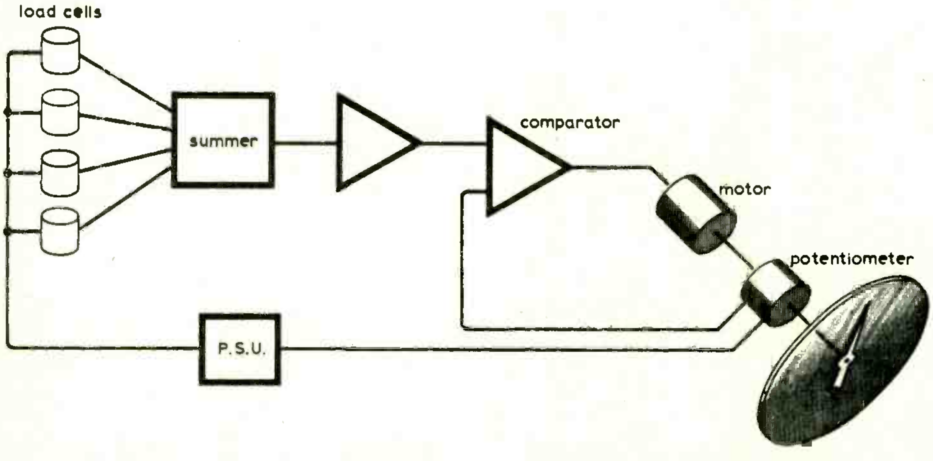



*Fig. 3. A dial indicator in basic form. Batching can be carried out either by using the analogue signal or by causing the pointer to actuate photo-cell or inductive trips.*

**Manufacturers of load cells and systems**

W. & T. Avery Ltd., Smethwick, Warley, Worcs. 021-558 1112/2161.
Bofors Electronics Ltd, Orchard House, Cherry Orchard Road, Croydon. 01-686 9487.
Davy-United Instruments Ltd, Darnall Works, Sheffield 9. Sheffield 49971.
Electromechanisms Ltd, 218/221 Bedford Avenue, Slough, Bucks. Slough 27242.
G.E.C.-Elliott Automation Ltd., Elstree Way, Borehamwood, Herts. 01-953 2030.
Guest International Ltd, Redlands, Coulsdon, Surrey CR3 2HT. 01-668 7141.
Hunting Engineering Ltd, Electrocontrols Division, Dallas Road, Bedford. Bedford 60181.
Mangood Ltd, Polo Fields Estate, Panteg, Pontypool, Mon. NP4 5YJ. 04955/55112.
Pye Ether Ltd, (Philips), Caxton Way, Stevenage, Herts SG1 2DG. 0438 4422.
Transducers (CEL) Ltd, Trafford Road, Reading, RG1 8JH. 0734 580166.

# An Approach to Audio Amplifier Design

## 2. Measurement of characteristics, transient considerations, transient intermodulation index.

*by J. R. Stuart,*B.Sc.(Eng), M.Sc., D.I.C., M.I.E.E.*

In the first part of this series the discussion of an approach to the design of audio systems led to consideration of some of the characteristics that are currently measured for evaluation purposes, and to some that are not, but could be.

It is easiest of course to measure systems in terms of deviations from the specified ideal, and here I have concentrated on measurements made with standard equipment. Discussion of the design of audio amplifiers has so far isolated the following parameters for examination, and an attempt has been made to apply a level of significance to each.

Steady state:

1. Frequency/amplitude and phase responses.
2. Steady-state harmonic and intermodulation distortions.
3. Specific waveform distortions e.g. crossover, clipping.

Transient:

1. Rise-time.
2. Stability.
3. Transient intermodulation distortions (t.i.d.).

Necessarily any discussion of these parameters is intimately involved with negative feedback design, and I return to this subject in this article.

**Sensitivity of the ear to changes of slope around zero.** The two distortion effects which, apart from serious overloading, seem to be the most objectionable to the ear are crossover and transient intermodulation distortion. Both effects can arise in any class AB or class B amplifier. The causes of both types of distortion are totally different and the designer can handle them independently. In general the values of these distortions are also independent of each other, but in the case of t.i.d. the presence of crossover distortion due to the gain deviation in the crossover region could aggravate the situation. It may be significant that both the distortions appear to have a similar subjective effect—possibly as both create a slope error (usually around the zero point)—although it may be an indirect consequence of these.

### Measurement of amplifier open loop characteristics

In conventionally designed negative feedback audio amplifiers, and particularly in power amplifiers, the open loop frequency response is normally determined by lag compensation applied to the loop, although in some cases transistor characteristics may dominate, e.g. when output transistors are operated in the common-emitter mode.

The problem of measuring the open-loop transfer characteristic is that usually the a.c. feedback loop is associated with d.c. feedback, and thus d.c. feedback is essential to the correct operation of the amplifier; also the measurement technique should not substantially alter the compensations and working conditions from those of closed-loop operation.

Figs. 11(a) and (b) show two common circuit configurations with all the usual lead and lag combinations. The technique proposed for measuring the forward characteristic is to divide $R_f$ into three elements as shown in Fig. 11(c), and to use two by-pass tantalum capacitors $C_a$ whose value is such that the attenuation between points A and B at the measuring frequency is at least 20dB more than the measured gain. As power amplifiers normally have a closed-loop gain of at least 20dB, the error in this measurement is likely to be less than 2dB. Note that this technique maintains fairly well the impedances at points A and B and

*Lecson Audio Ltd

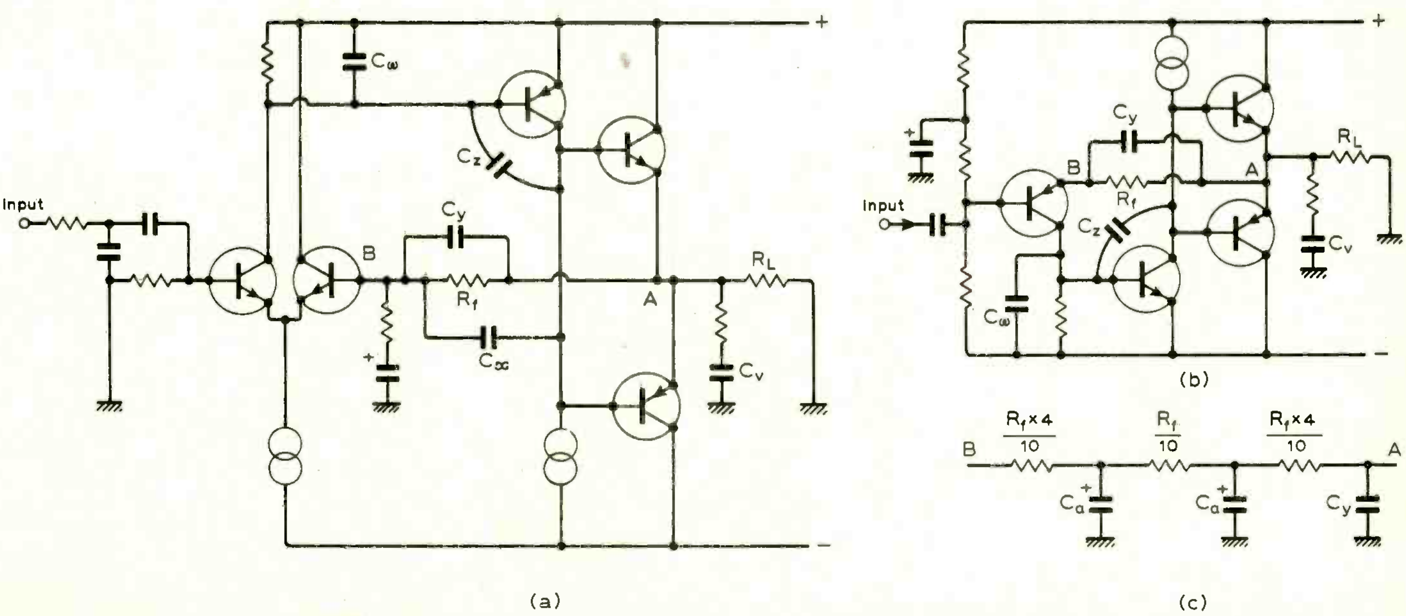



*Fig. 11 (a), (b). Two typical amplifier configurations used to establish methods of measuring open and closed loop circuit performance. (c) Substitution of feedback resistor $R_f$ by test jig circuit.*

does not interfere with the conservative compensation of $C_x$ or the loading of $C_y$.

This connection, with careful attention paid to stray capacitances, will allow the measurement of open-loop gain and phase (compensated and uncompensated) and open-loop distortion.

### Some transient considerations

At the end of the first part in this series, a list of conclusions leading to the avoidance of t.i.d. were given in terms of negative feedback-loop design considerations. To obtain the best reproduction from an amplifier, careful attention has to be paid to other transient distortion mechanisms which include waveform distortions like ringing and overshoot and low-frequency rumble effects.

One very interesting property of negative feedback loops is that whereas usually their action is to reduce distortion appearing at the output, waveforms inside the loop may be subject to very large amounts of distortion—much more than in the open-loop condition. I have quite often measured distortions within a loop 1000× the output distortion when only 30dB of feedback is being used.

Low frequency transient effects can then arise if this distorted signal is able to change the d.c. working points of any stage in the amplifier, e.g. modify the average current in a decoupled stage as in Fig. 12. This is further aggravated, or may be induced, if the design allows the application of more d.c. than a.c. feedback. This is commonly done in an attempt to achieve an apparently high d.c. stability. In practice, small differences in the gain of the two halves of an amplifier can result in large very low frequency error signals being generated which can cause clipping or aggravate other distortions. The effect, which can be considered as a dynamic offset, is shown up by tone-burst testing.

**Transient response, distortion and stability.** The synthesis of a successful system, and of single-loop forward characteristics, relies heavily on judgements made in balancing the above three characteristics.

Curve 1 in fig. 13 is an uncompensated amplifier response shown as a Bode plot. Were this amplifier connected for a closed-loop gain of GdB it would be unstable. This is made more clear in the $j\omega$-plane Nyquist plot of Fig. 14.

There are three important ways in which this amplifier may be stabilised. The first is to very conservatively compensate it to achieve unconditional stability by rolling off the gain at a very controlled $-20$dB/decade. This makes it necessary to introduce a dominant pole, sufficiently low in frequency, say at $\omega_c$, to ensure that either the loop gain $A\beta$ has fallen to 0dB by the second open-loop breakpoint $\omega_\beta$, or that it is possible to add some lead compensation to the original response—or the feedback network—to allow a little less drastic compensation. The results of these suggestions are illustrated as curves 2 and 3 in Figs. 13 and 14. One implication is that unless the designer can find more gain in the forward characteristic $A(s)$, or is prepared to add a

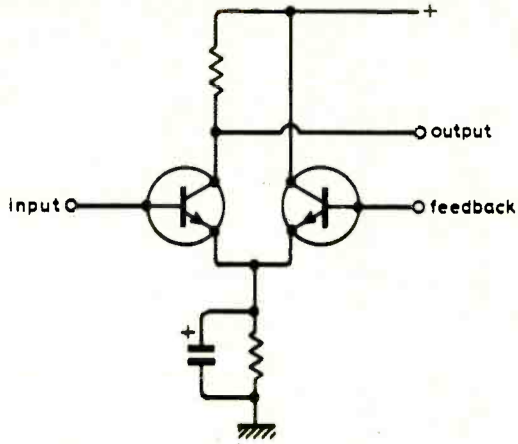



*Fig. 12. Typical d.c. coupled amplifier.*

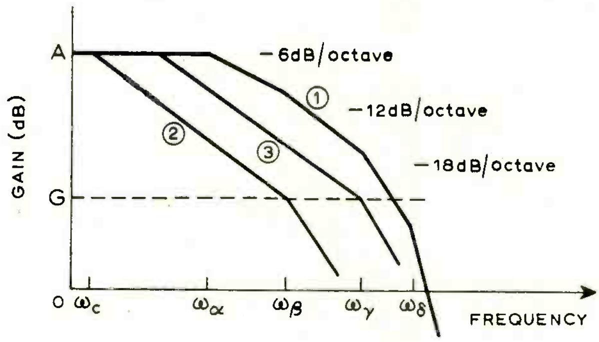



*Fig. 13. Bode plot of a typical uncompensated amplifier.*

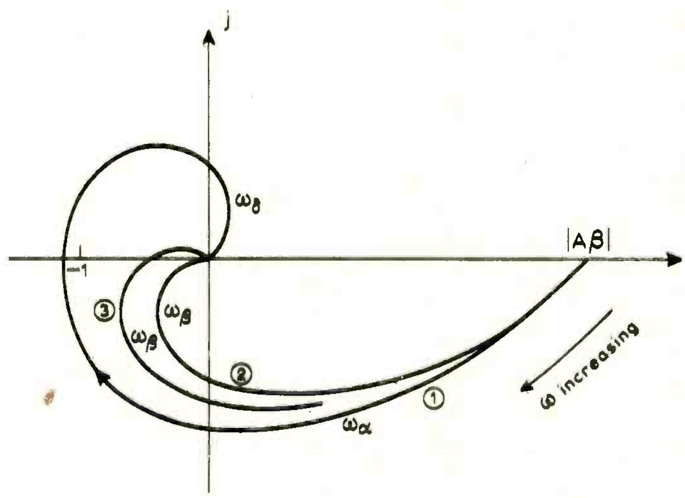



*Fig. 14. Nyquist plot of amplifier example shown in Fig. 13.*

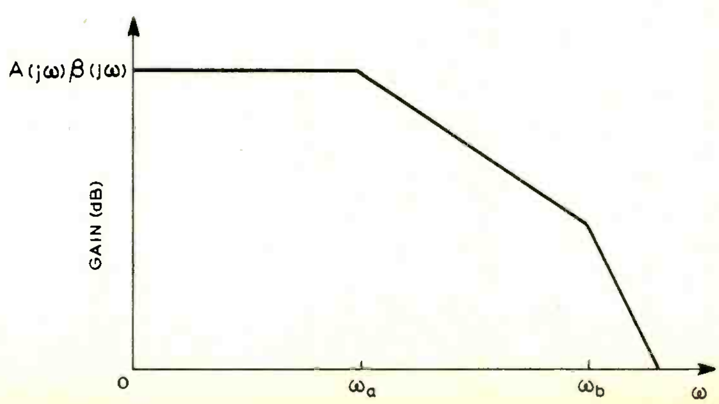



*Fig. 15. Loop gain characteristic of a marginally stable amplifier.*

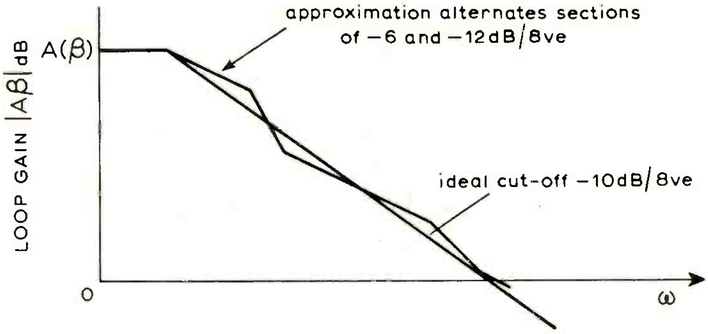



*Fig. 16. An approximation to the ideal Bode loop gain characteristic.*

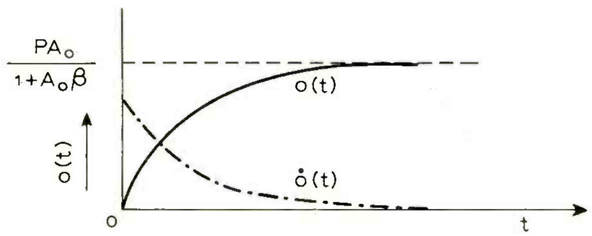



*Fig. 17. Response of an amplifier with ideal Bode plot of Fig. 15, to a step function.*

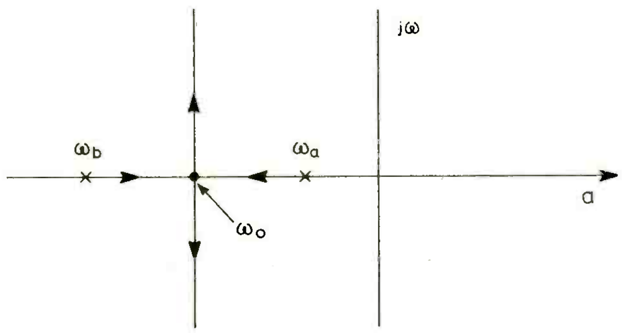



*Fig. 18. An s-plane plot showing the effect of negative feedback on the natural frequencies of the two pole system shown in Fig. 17.*

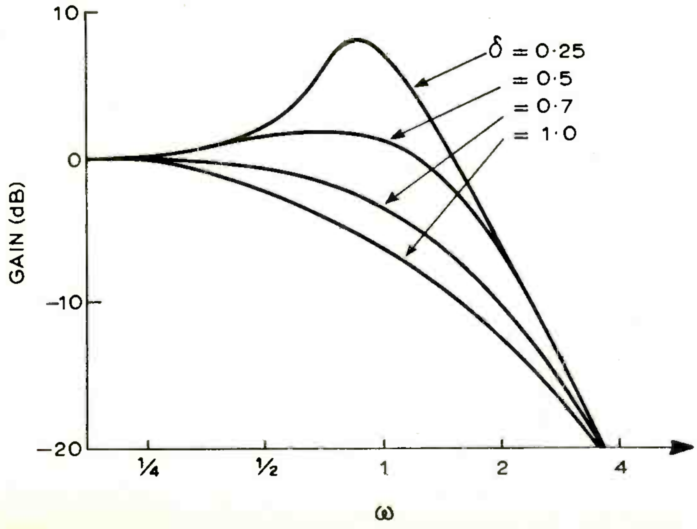



*Fig. 19. The peaking of frequency response as a result of the application of more feedback which, in turn, reduces damping.*

zero to the feedback network at $\omega_\beta$, then unconditional stability can only be achieved by accepting that the feedback will become inoperative at $\omega_\beta$.

An alternative method is to accept a marginal stability and hence permit a loop gain characteristic $A(j\omega)$, $\beta(j\omega)$ like that shown in Fig. 15. A characteristic of marginal stability is that such an amplifier may have a transient response which exhibits an overshoot or an oscillatory mode, and a peaking in the frequency response.

The third technique, of course, is to approximate to Bode's ideal loop gain characteristic as shown in Fig. 16. The first two cases will now be considered:

**Unconditional stability.** An amplifier whose ideal forward characteristic (see Fig. 16)

$$A(s) = A_o \cdot \frac{a_o}{s+a}$$

is connected as a feedback amplifier where $\beta(s)$ = constant $\beta$. The closed loop gain $G(s)$ is given by

$$G(s) = \frac{aA_o}{s+a(1+A_o\beta)} \qquad (1)$$

showing that the low frequency gain is reduced by the factor $(1+A_o\beta)$, along with noise and steady distortions, while the bandwidth has been increased to $a\,(1+A_o\beta)$. Here $aA_0$ is the gain bandwidth product.

The response of this circuit to a step function, value $p$, is given by

$$o(s) = \frac{p}{s} \cdot \frac{aA_o}{s+a(1+A_o\beta)}.$$

This gives by inverse Laplace transformation the output $o(t)$.

$$o(t) = \frac{pA_o}{1+A_o\beta}\,[1-\exp-(a(1+A_o\beta)t)]$$

These are sketched in Fig. 17 along with the impulse response $\dot{o}(t)$ where $\dot{o}(t) = g(t)$. It can be seen that no overshoot or ringing is possible in this circuit, and this kind of step response is one which many audio designers try to achieve.

**Marginal stability.** This is the condition where $A(j\omega),\beta(j\omega)$ is arranged so that when $|A(j\omega),\beta(j\omega)| = 1$ there exists a phase margin, $\theta$, such that $\pi/2 > \theta > 0$. (Note: for conditional stability the relationship could be $\pi/2 > \theta > -\pi/2$.)

The phase margin $\theta$ is determined from $\theta = \pi - \angle A(j\omega_1),\beta(j\omega_1)$. The most general open-loop response that can be used successfully for closed-loop gains $\geqslant 1$ is the two-pole system shown in Fig. 15 and the open-loop response

$$A(s) = \frac{A_o \cdot a \cdot b}{(s+a)(s+b)}.$$

When the loop is closed this gives the form:

$$G(s) = \frac{A_o \cdot a \cdot b}{s^2+s(a+b)+ab(1+A_o\beta)} \qquad (2)$$

The effect of negative feedback on the natural frequencies of this network is shown in the $s$-plane plot of Fig. 18. Notice that with sufficient feedback the two poles coincide at $s_o = \sqrt{(1+A_o\beta)ab}$.

The damping factor

$$\delta = \frac{1}{2Q} = \frac{a+b}{2\sqrt{(1+A_o\beta)ab}}.$$

Note that the damping is inversely proportional to $\sqrt{1+A_o\beta}$ so, as would be expected, the application of more and more feedback reduces the damping, increases the peak in the closed-loop response and introduces an oscillatory mode to the step response for $\delta < 1$,* see Fig. 19 curves. This arises because the roots of the denominator of equation 2 become imaginary. Commonly used criteria to determine whether the transient response of such a circuit will be adequate are gain and phase margins, and the amount of peaking shown in the steady-state frequency response. To some extent, the values chosen depend upon gain and phase stability, and variability within the design, but rules of thumb suggest that $\delta \geqslant 1/\sqrt{2} \geqslant Q$, and suggest gain and phase margins of 15dB and 60°.

**Reactive load conditions.** One problem in the design of an audio power amplifier is that it may be expected to drive loads varying from pure inductance through resistance to pure capacitance, and may also be loaded with a tuned circuit.

So far as stability is concerned the inductive load does not concern us much† as it is assumed that the open-loop transfer characteristics referred to are measured or calculated under resistive loading.

Loading a practical amplifier with a pure capacitance, to simulate perhaps electrostatic loading, will result in the introduction of a new pole in the transfer function at $\omega_n$. It can be seen from Fig. 20(a) that the effect of this on an unconditionally stable amplifier is that for $\omega_n$, $\omega_{n1} \angle \omega_a(1+A_o\beta)$ a ringing may appear in the closed loop step response, whereas little change will occur in the step response if $\omega_{n1} > \omega_a(1+A_o\beta)$.

In an amplifier of 2nd order response working into a resistive load, the effect of adding the pole $\omega_n < \omega_x$ can be to make the amplifier unstable; or for $\omega_n > \omega_x$ little change should be noted. See Fig. 20(b).

**Capacitive load condition.** One technique often used to ensure stability and/or freedom from overshoot into capacitive loads is to deliberately over compensate the open-loop response so that at no time does $\omega_n$ fall below the closed-loop cut-off frequency. This technique is unnecessarily punitive and will obviously result in a lower open-loop break-point.

Another technique is to modify the output circuit so that although $\omega_n$ can be $\ll \omega_x$, the change to the open-loop response is small, ensuring that at $|A(j\omega)| = \beta^{-1}$ the slope of $A(j\omega)$ is the same as in the resistive termination. Such a modification involves a resistor and inductor in series with the output. This is shown in Fig. 20(c).

The last technique to take account of this type of loading involves adding a zero to the

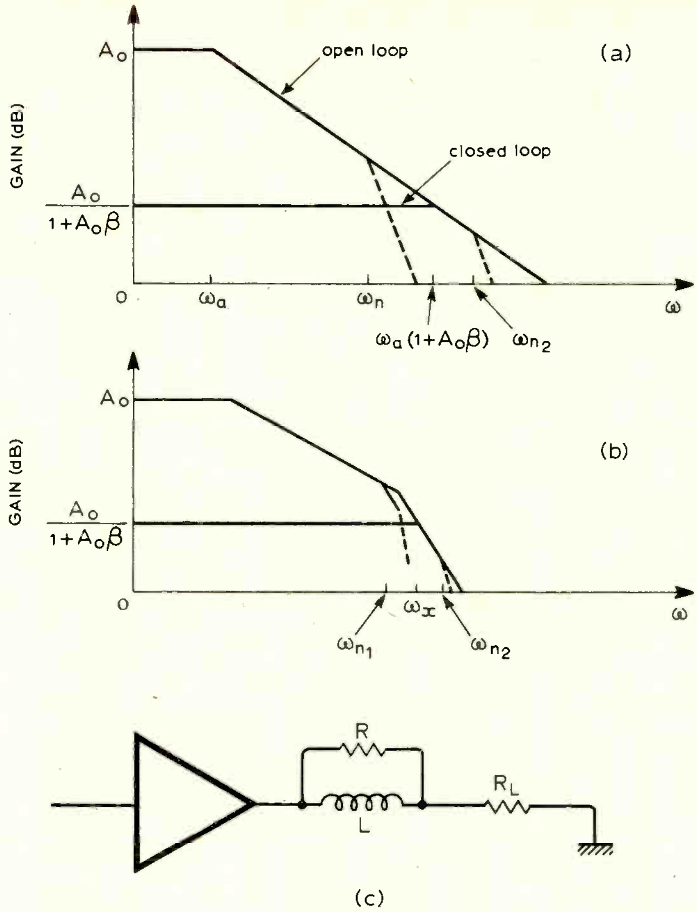



*Fig. 20. Effect on single pole (a) and two pole (b) amplifiers of driving into a purely capacitive load. (c) Output circuit modification to improve stability with a capacitive load.*

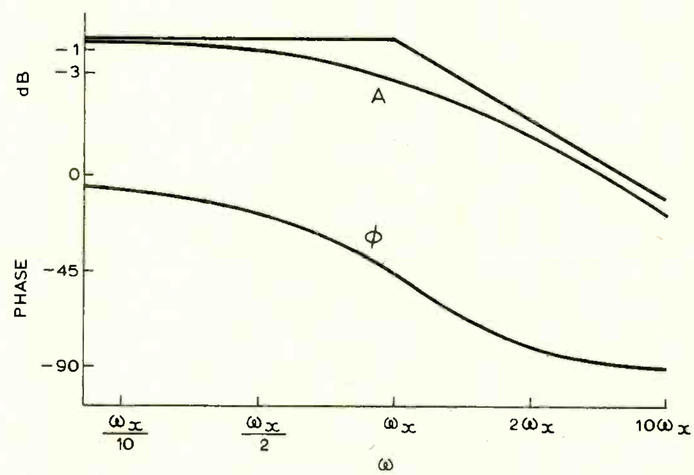



*Fig. 21. Loop gain and phase characteristics of single pole amplifier.*

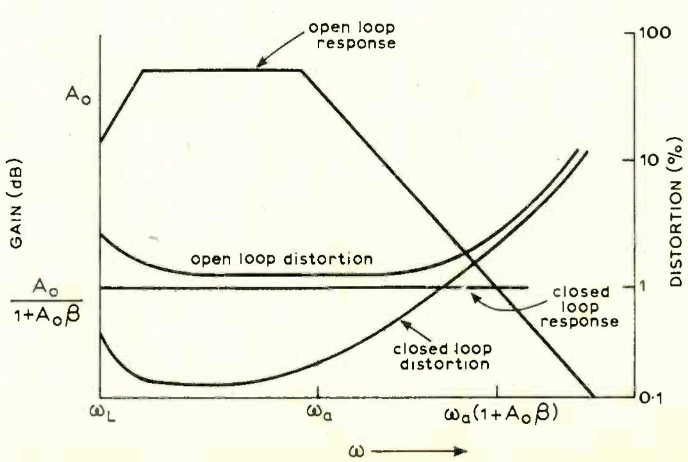



*Fig. 22. The projected effect on distortion of the amplifier loop characteristic.*

*Critical damping

†Note: the inductive load is important when considering low frequency design.

feedback network; hence $\beta(s)$ is of the form:

$$\beta(s) = \frac{s+m}{m} \cdot \beta$$

This of course has the effect of adding a zero to the closed-loop transmission, and if $m$ is chosen to be equal to $\omega_n$ for the largest value of capacitor load envisaged, say 2μF, then the transient response and stability will not suffer provided $\omega_n > 50$kHz (for an audio amplifier).

### Phase response

Neglecting for the moment the example of an amplifier with a second order open-loop response, let us consider the responses of the single pole example shown in Fig. 21 having its pole at $\omega_x$. If we consider the closed-loop response of the system we can see that this also described the closed-loop responses where

$$\omega_o(\text{closed loop}) = (1 + A_o\beta)\omega_o$$

The specification for a high quality amplifier quoted in the first part of this series contained the suggestion that the amplifier as a whole should have phase tolerances of $\pm 10°$. Given that a passive filter was shown to be desirable in the pre-amplifier, for transient distortion reasons, and that this will introduce a phase lag, it can be seen that the permissible phase shift in any one stage is small, and ideally $-2°$ at 20kHz in a typical system. Note that this and the requirements for stability apply equally to the low frequency design. An amplifier with a response of the form

$$G(s) = \frac{A_o \cdot a}{s + a(1 + A_o\beta)}$$

will have a phase shift of $-2°$ at 20kHz for $\omega_x = \sin\omega_a(1 + A_o\beta) = 570$kHz and $-6°$ for $\omega_x = 200$kHz.

This result suggests that the phase requirement places fairly strict bounds on the gain-bandwidth product for any design; e.g., if we wish to have a phase lag of $-2°$ at 20kHz and to use 40dB of feedback then the open-loop pole $\omega_a = 5.7$kHz min.

In the second order case the requirement for a given phase lag will be a greater open-loop $-3$dB bandwidth due to the more rapid open-loop phase shifts.

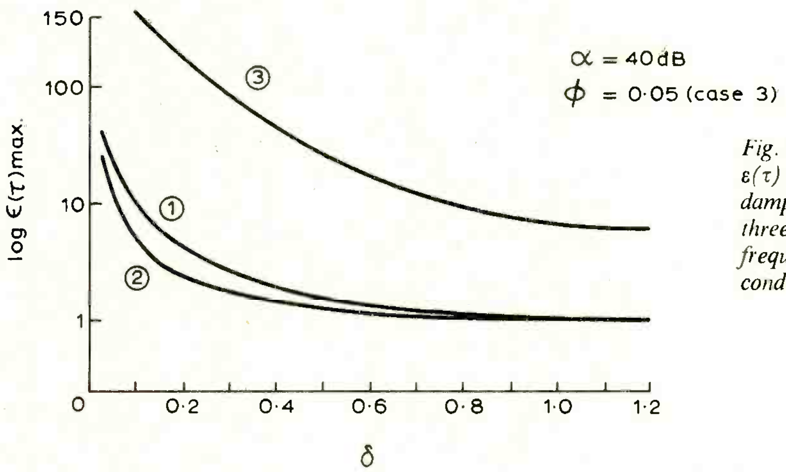



*Fig. 23. Values of ε(τ) plotted against damping factor for three different frequency response conditions.*

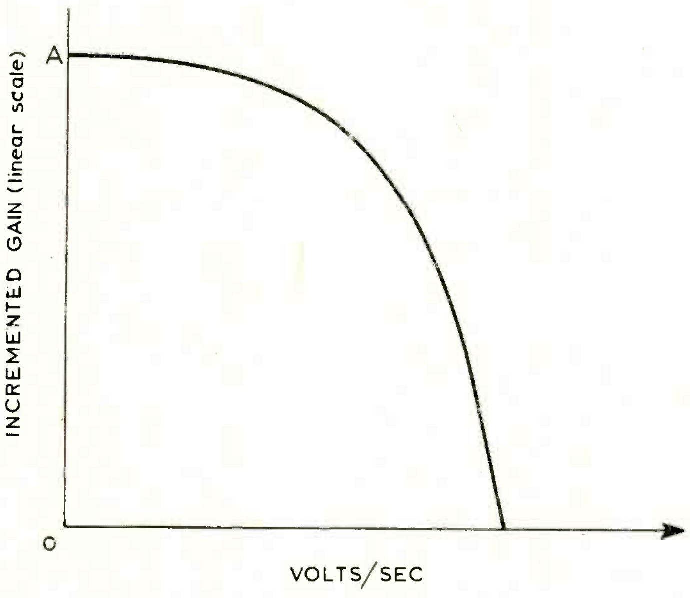



*Fig. 24. Model of performance as a function of input slew rate.*

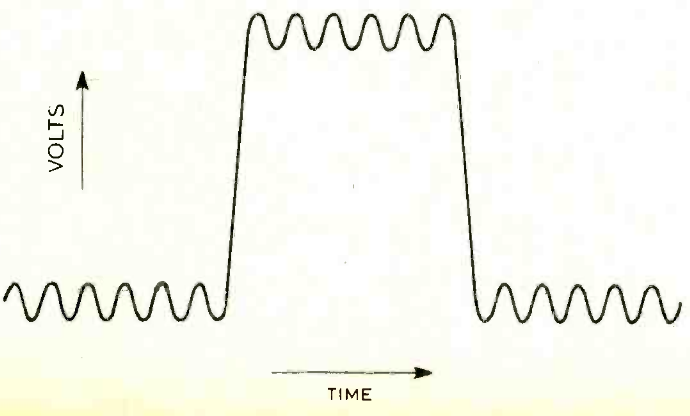



*Fig. 25. Test signal used to probe incremental gain.*

### Distortion reduction

A point was made in the first part of this series that a weighted steady-state distortion of 0.1% at any frequency in the audio band was a good and sufficient goal at which to aim. In addition, general discussion of the mechanism of negative feedback loops produced three points:

1. The steady-state distortions, amenable to reduction by feedback, are not reduced for a signal of frequency $\omega_1$ by the amount $(1 + A(j\omega_1),\beta(j\omega_1))$ but by an amount related to $(1 + A(jn\omega_1),\beta(jn\omega_1))$ for $n$, integer $\geqslant +2$. This accounts for any reduction of loop gain at harmonic frequencies and phase shifts at these frequencies.
2. The weighted steady distortions in an amplifier where $A(j\omega) = $ constant, $\omega = 0$ to $\pm\infty$, will only reduce by the amount $(1 + A\beta)$ if the distortions are already small, so that $A\beta(v)$ has small limits; otherwise not only will the t.h.d. not reduce, but the weighted t.h.d. can be expected to reduce less, due to a changed harmonic structure being introduced.
3. It is likely that negative feedback will reduce the maximum unclipped output.

Fig. 22 illustrates the expected effect of the loop characteristic on the distortion of an amplifier. Obviously the only two points the designer must carefully consider are the extremes of the range—as would be expected. The arguments of course apply equally to intermodulation distortion.

It can be seen that for any particular specification, e.g. $\ngtr 0.1\%$ weighted t.h.d. in the band 20Hz–22kHz, the open-loop gain and phase response will be an important consideration, a wider bandwidth giving a neater solution to the t.h.d. specification and making it necessary to obtain a given distortion characteristic, to use less low frequency gain and hence achieve better stability, and phase response.

### System transient analysis

In analysing the transient performance of a system, that is pre-amplifier plus power amplifier, the power amplifier has been considered as having a first order open-loop response—or at least a second order response where $\omega_b \gg \omega_a$ (Fig. 15). This has been done for simplicity; however, the conclusions are general. Three conditions have been envisaged:

1. Pre-amplifier response declines at $-6$dB/octave above $\omega_1$.
2. Pre-amplifier response declines at $-12$dB/octave above $\omega_1$.
3. Pre-amplifier response is boosted by $+6$dB/octave above $\omega_2$ and decays at $-6$dB/octave above $\omega_1$.

In each case the power amplifier has an open-loop pole at $\omega_o$ and has a response

$$\frac{e_o}{e_1} = G(s) = \frac{A \cdot \omega_o}{s+\omega_o(1+A\beta)}.$$

The error signal $\varepsilon$ is described by the relationship

$$\frac{\varepsilon}{e_1} = K(s) = \frac{s+\omega_o}{s+\omega_o(1+A\beta)}.$$

Put $(1+A\beta) = \alpha$ in case 1, then, the total input–output response is given by:

$$H(s) = A \cdot \frac{\omega_1}{(s+\omega_1)} \cdot \frac{\omega_o}{(s+\alpha\omega_o)}$$

and in response to step function value $p$, the output is given by:

$$e_o(s) = \frac{p}{s} \cdot \frac{A\omega_o\omega_1}{(s+\omega_1)(s+\alpha\omega_o)}$$

and the error signal:

$$\varepsilon(s) = \frac{p}{s} \cdot \frac{(s+\omega_o)}{(s+\omega_o\alpha)} \cdot \frac{\omega_1}{s+\omega_1}$$

Taking partial fractions we deduce that

$$\frac{\varepsilon(s)}{p} = \frac{1}{\alpha s} + \frac{\dfrac{\omega_1(1-\alpha)}{\alpha(\omega_o\alpha-\omega_1)}}{[s+\omega_o\alpha]} + \frac{\dfrac{\omega_1-\omega_o}{(\omega_o\alpha-\omega_1)}}{[s+\omega_1]}$$

Setting $\omega_o/\omega_1 = \delta$ and $\omega_1 t = \tau$ and using the reverse Laplace transform we get

$$\varepsilon(\tau) = \frac{p}{\alpha}\left[1 + \frac{(1-\alpha)}{(\alpha\delta-1)} \cdot \exp(-\delta\alpha)\tau - \frac{\alpha(1-\delta)}{(1-\alpha\delta)}\exp-\tau\right] \quad (5)$$

By differentiating $\varepsilon(\tau)$ and setting this signal to zero we get the stationary points. Other than at $\tau = 0,\infty$ there is a value of $\tau$ for which $\varepsilon(\tau)$ is a maximum given by:

$$\tau = \frac{1}{(1-\alpha\delta)}\ln\frac{(-\delta)}{\delta(\alpha-1)} \quad (6)$$

The value of $\varepsilon(\tau)$ for various values of $\alpha$ and $\delta$ are plotted in Fig. 23. A similar analysis shows for case 2,

$$\varepsilon_2(\tau) = \frac{p}{\alpha}\left[1 + \frac{(1-\alpha)}{(1-\alpha\delta)}\exp(-\alpha\delta\tau) + \left\{(\delta-1)\tau - \frac{1-\delta(2-\alpha\delta)}{(1-\alpha\delta)}\right\} \frac{\alpha}{1-\alpha\delta} \cdot \exp-\tau\right] \quad (7)$$

and for case 3

$$\varepsilon_3(\tau) = \frac{p}{\alpha}\left[1 + \left\{\frac{(1-\alpha)}{(1-\alpha\delta)} \cdot \frac{(\alpha\delta-\phi)}{\phi(1-\alpha\delta)}\right\} \exp(-\alpha\delta\tau) + \left\{(\delta-1)(\phi-1)\tau - \phi(\delta\phi-1) + \frac{(\delta-1)(\phi-1)}{(1-\alpha\delta)}\right\} \cdot \frac{\alpha}{\phi(1-\alpha\delta)}\exp-\tau\right]$$

where $\phi = \omega_2/\omega_1$.

The values of $\varepsilon(\tau)$ are also shown for cases 2 and 3 in Fig. 23. It is clear that the form of $\varepsilon(\tau)$ allows quite large overshoots to occur in the feedback loop and these can have a peak value much larger than the steady state error signal for the highest frequency $\omega_1$. It is interesting to consider the reason for this, and once again the surprise can be traced back to the classical feedback model. In the open-loop amplifier, the time for the output to rise from 10% to 90% of the final value was given as $0.35/2\pi\omega_o$ sec. Now when the loop is closed, to achieve the original output level, instead of this condition, the effective input signal is increased in an attempt to increase the output slew-rate.

The classical theory breaks down here, because in a practical amplifier the following conditions will be obtained:

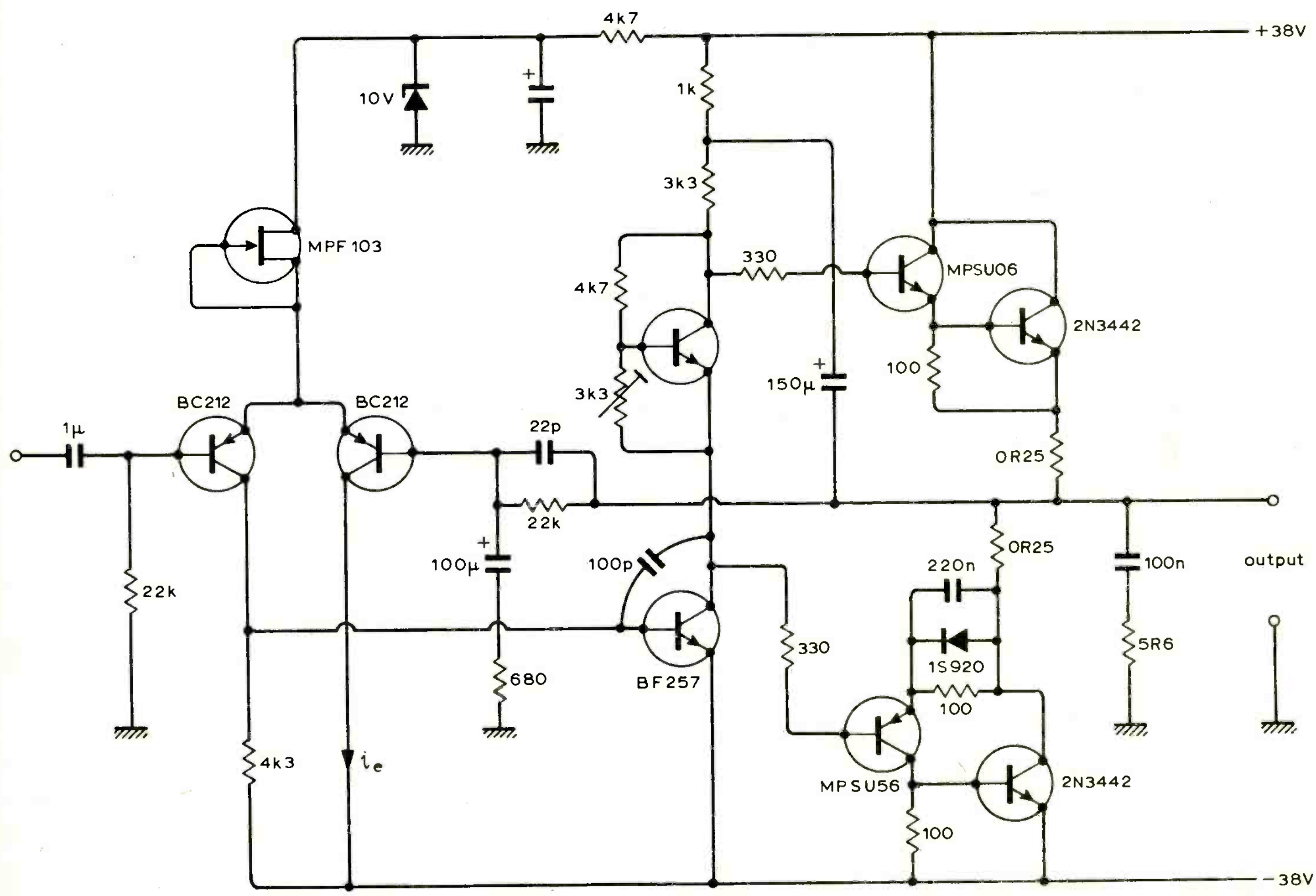



*Fig. 26. Basic amplifier design produced to test transient distortion analysis.*

● The amplifier will exhibit a time delay.
● The output slew-rate will not increase indefinitely in response to increased input signal level.
● In practice there will be a maximum slewing rate for the amplifier ($S_{out}$ volts/sec) which is determined by the internal time constants and overload margins. At this point the relationship $S_{out} = AS$ totally breaks down.

This amounts to the feedback network being totally inoperative for a portion of the open-loop rise-time of the amplifier, which can in turn have three effects:
● The incremental gain of the amplifier is not controlled during this time.
● The resulting overshoot in $\varepsilon(\tau)$ can overload the early stages of the amplifier, resulting in a 100% intermodulation during the rise time.
● The overshoot may, depending on the amplifier recovery characteristics, cause the amplifier to latch-up, resulting in an intermodulation burst much longer than the rise-time. The burst is commonly several milliseconds in many commercial amplifiers, particularly if an amount of treble boost is applied as in case 3.

The transient distortion need not produce 100% i.m.d. since amplifiers tend to overload progressively. Fig. 24 is a model of performance as a function of the input slew rate $S_{in}$. The incremental gain will, of course, indicate the amplifier's ability to handle any other signal present before, during and after the transient. A useful test signal to probe this is shown in Fig. 25.

It will be remembered that the sensitivity of the ear to changes of slope was discussed earlier. It seems that there will be an equal likelihood of response to gain deviation in the vicinity of a transient as to disappearance of the incremental gain.

## Transient intermodulation index

Transient distortion can be analysed statistically, the likelihood of such a distortion arising being dependent upon the probability that an overshoot will arise within the loop sufficient to cause a significant gain deviation. This can in turn be related to the product of two parameters, the transient intermodulation index (t.i.i.), which describes the maximum size of overshoot expected from the previous analysis, and the overload margins in the amplifier.

The transient intermodulation index has been proposed here to give a rough idea of the amplifier's susceptibility to this form of trouble, and has been normalised so that an amplifier considered to have a good quality, judged by listening experiments and having, say, 20kHz open-loop bandwidth with 40dB of feedback, is normalized to 0.1.

From the analysis it can be seen that the size of an overshoot could be approximately proportioned to $F/\delta$ where $F$ is the feedback factor. The important thing to note here is that $\delta$ refers the signal bandwidth to the open-loop bandwidth and so this relationship can be applied to any stage in the amplifier.

**An example:** To test the analysis an amplifier was built as shown in Fig. 26. It is a very common circuit and there is nothing special about the way the forward compensation has been applied. The dominant open-loop pole is set by $C_y$ and, as can be seen from the steady-state summaries in Fig. 27, the performance is nothing special. However, it is typical of the configuration which, due to device limitations, can never achieve the ultimate quality of alternative circuits.

Two experiments were carried out and in each case the input signal was passed through a network with a single pole at 44kHz. In the first a square wave was applied at 1kHz p.r.f. and 2μs rise and fall time and the error signal was measured for 20V peak to peak output. This waveform is shown in Fig. 28. Note that the overshoot is 350 × the steady-state error in the negative direction and that in the positive direction the error is clipped at 70 × the steady-state error.

Secondly, a 20kHz sine wave of 1V peak to peak was added to the input signal and, as Fig. 29 shows, a transient distortion occurred, which was considerably aggravated for both positive and negative excursions by the addition of a capacitive load.

Now obviously this can be much improved by increasing the overload margins of the first stage. Even when the situation

*Fig. 27. Graphical summary of steady state performance of amplifier design shown in Fig. 26.*

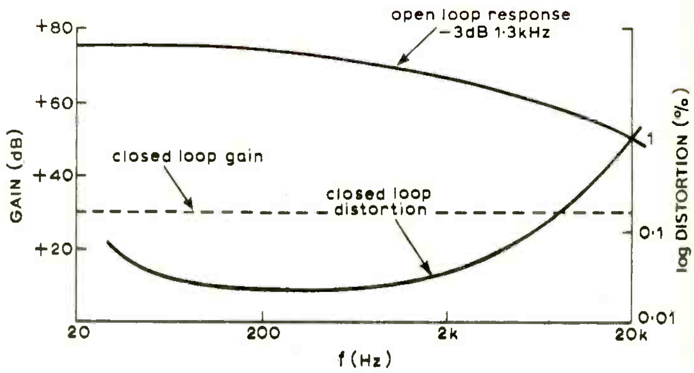
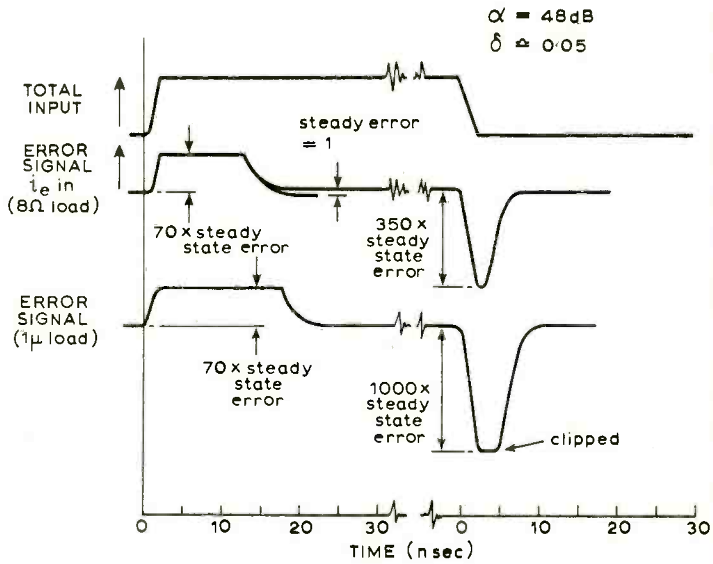



*Fig. 28. Transient response to the test amplifier to square wave test signals for a resistive 8 load and a 1 F capacitive load.*



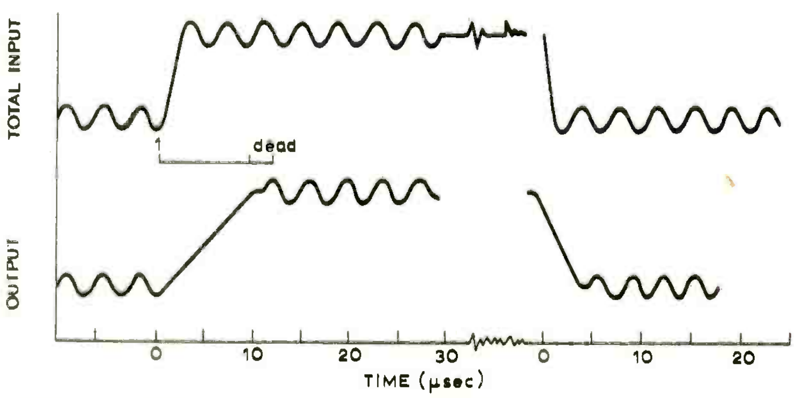




*Fig. 29. Effect of combining a sine or square wave to demonstrate t.i.d.*

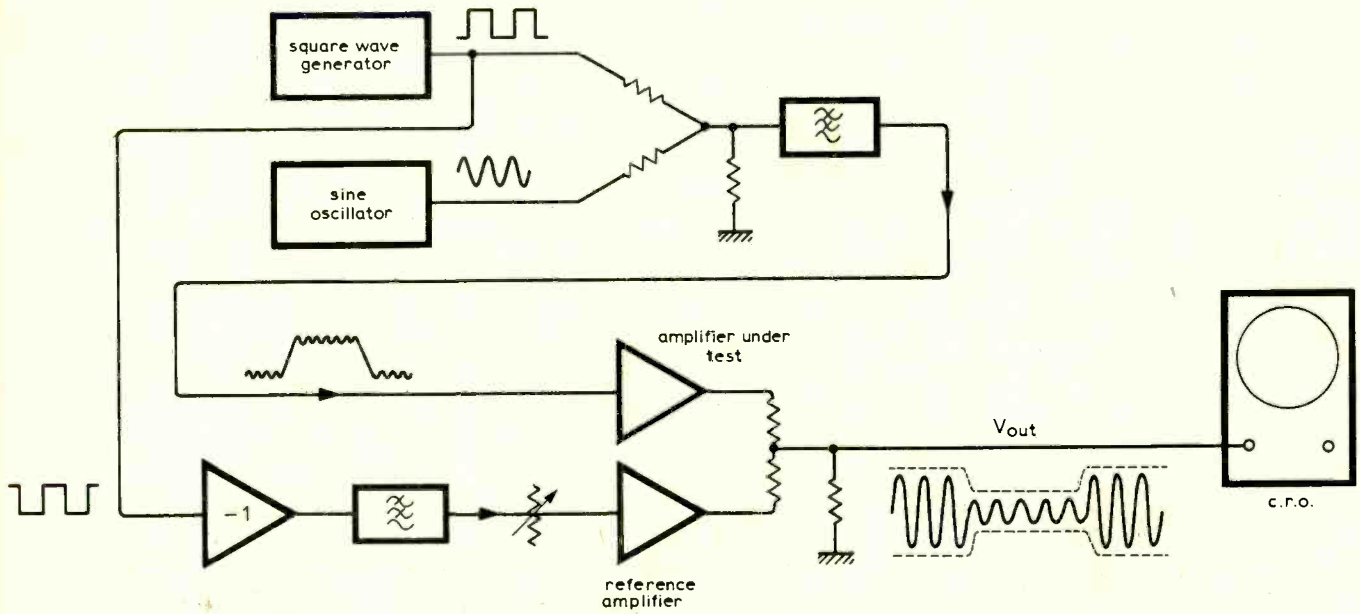



*Fig. 30. Test rig used to measure t.i.d.*

can be arranged so that the gain does not disappear, experiments indicate that the oscilloscope is not sensitive enough to show up the sort of gain deviations to which the ear responds. It is quite difficult to see 5% t.h.d. as a sine wave.

One technique I have used to increase the sensitivity of the sine plus square test is shown in Fig. 30. Here, the square-wave is modified by a phase characteristic equal to that of the amplifier under test, e.g. a duplicate amplifier, and the resulting signal is subtracted from the output waveform. The resulting signal allows 5% gain deviation to be seen.

### The treatment of steady distortion

The transistor is basically non-linear in many respects, and the designer of any equipment must understand this completely to design predictively. It is convenient to consider the non-linearities of the transistor in three cases:

- Small signal conditions, high and low frequency.
- Large signal, low frequency.
- Large signal, high frequency.

The small signal condition is, however, best considered as a special case of the large signal, except that some useful analyses are available on the minimization of second-harmonic distortion in small signal stages. Owing to the general shape of the polynomial describing the basic relationship between collector current ($i_c$) and base current ($i_b$) the predominant distortion is normally second harmonic. At low frequencies the non-linearities are (Fig. 31):

- The exponential form of the relationship between $i_b$ and $V_{be}$, and of $V_{be}$ with temperature.
- Variations of $h_{fe}$ and $h_{FE}$ with collector current $i_c$ and with collector emitter voltage $V_{ce}$. The variation of $h_{fe}$ with high values of $V_{ce}$, which is due to narrowing of the base area (Early effect). Also $h_{fe}$ is subject to variation with temperature.

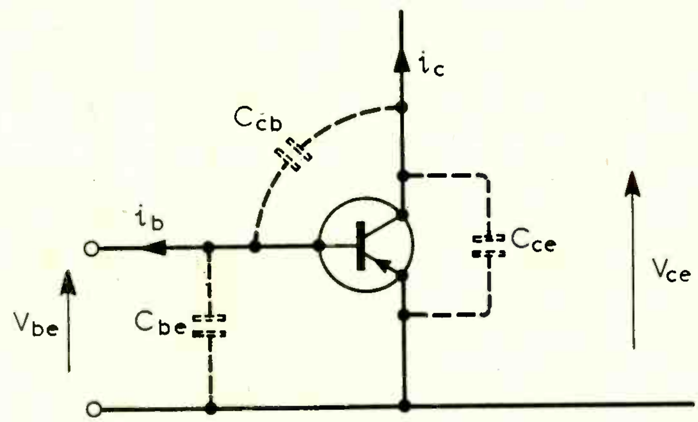



*Fig. 31. Sources of non-linearity in a transistor.*

At high frequencies the following effects are to be added:

- Variations of $C_{be}$, $C_{cb}$ and $C_{ce}$ with device temperature, $V_{ce}$ and $i_c$.

Particularly for large signals this amounts, or can amount to, large changes in gain (10 to 1000×), of any stage during a signal cycle, and particularly so at high frequencies.

The fundamental freedoms available to the designer are:

- Choice of device to optimise the effects for any circuit.
- Choice of quiescent operating conditions ($V_{ce}$ and $i_c$) and of large signal swings.
- Control of the source and load impedances. In particular, choice of the correct source impedance for a stage can be fundamental in reducing distortion.
- Choice of the amount of local feedback.

In part 3, further discussion of steady state distortions leads to a description of a recent design. The idea of a figure of merit is returned to and the results of experiments given together with some consequential proposals.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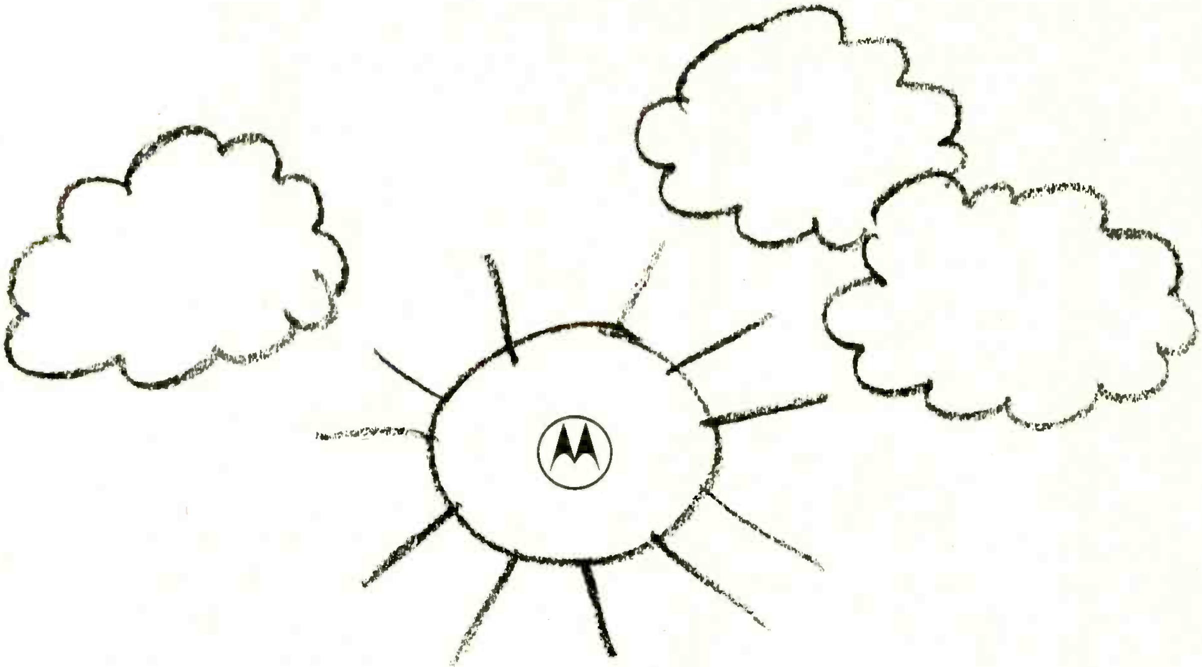

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# Experiments with operational amplifiers

## Conversions between time and other variables

*by G. B. Clayton,* B.Sc., F.Inst. P.*

In instrumentation systems it is sometimes necessary to change a signal from one form into another. Conversions which involve time, for example voltage to time conversion or time to voltage conversion, can be performed using an operational integrator as the basis of the conversion circuit. The experimental circuits presented here show some of the ways in which operational amplifiers can be used for time conversions.

### 13. Pulse height to time conversion

A circuit which can be used to produce a time interval proportional to the height of a positive input pulse is shown in Fig. 13.1.

The amplifier is connected as an integrator. In the absence of an input pulse the output voltage of the amplifier is held at approximately zero by the negative feedback through diode $D_3$. A positive input pulse causes capacitors $C_1$ and $C_2$ to charge, the output of the amplifier steps down and diode $D_3$ is reverse biased. If $V_p$ is the height of the input pulse the output steps down by an amount $V_p \cdot \frac{C_1}{C_2}$. This output step is discharged at the integrator at a rate $\frac{E_{ref}}{C_2 R}$ volts/sec. The time for the output to charge up back to zero is thus

$$t = \frac{V_p \frac{C_1}{C_2}}{\frac{E_{ref}}{C_2 R}} = \frac{C_1 R}{E_{ref}} \cdot V_p$$

This time period is directly proportional to the height of the input pulse. Scaling may be set by choice of $E_{ref}$.

Circuit performance may be checked by applying input pulses of different amplitude and measuring charging times by observation of oscilloscope waveforms. The action of the circuit is illustrated by the typical waveforms in Fig. 13.2, which show the circuit response for input pulses of two different heights.

*Department of Physics, Liverpool Polytechnic

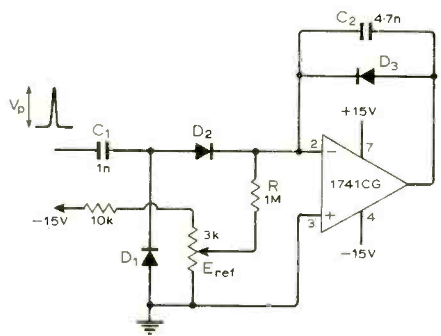



*Fig. 13.1 Conversion of pulse height to time.*

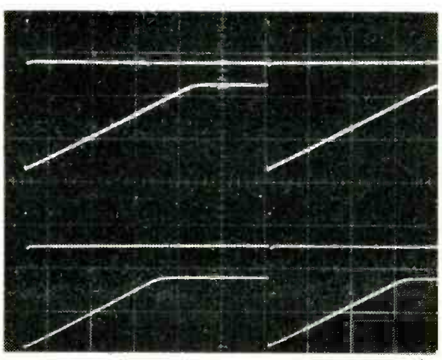


*Fig. 13.2 Action of Fig. 13.1 circuit illustrated by input pulses of different heights. Pulse waveforms, 10V/div; integrator outputs, 1V/div.; horizontal scale 1ms/div.*

### 14. Time to voltage conversion

A modification to the circuit of Fig. 13.1 which allows it to be used for a time to voltage conversion is shown in Fig. 14.1. The time interval to be converted is the time period of a negative gating signal. In the absence of a gating signal a positive voltage at point A causes conduction through diode $D_1$ and the output of the amplifier is held at approximately zero because of negative feedback through diode $D_2$. A negative gate applied at point A reverse biases both diodes and the output voltage of the amplifier rises linearly at a rate determined by $E_{ref}$ and the integrator time constant $CR$. The amplitude of the output ramp which is generated is proportional to the time period of the gating signal,

$$E_o = \frac{E_{ref}}{CR} \cdot t$$

where $E_o$ is the amplitude of the output ramp and $t$ is the time period of the gating signal.

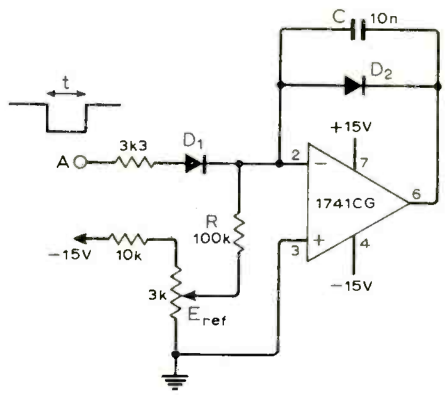



*Fig. 14.1 Circuit for time to voltage conversion.*

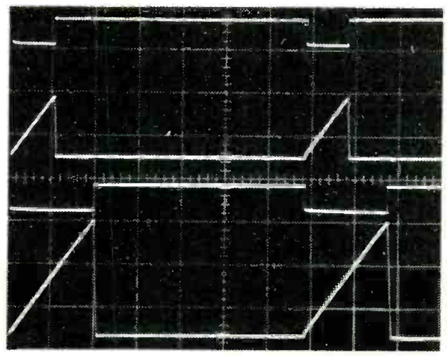


*Fig. 14.2 Action of Fig. 14.1 circuit illustrated by negative-going rectangular-pulse gating signals of different widths. Rectangular waves, 5V/div.; ramp waveforms 2V/div.; horizontal scale 2ms/div.*

Typical waveforms which may be observed in order to investigate the action of the circuit are shown in Fig. 14.2. The effect of two different gating periods is illustrated.

### 15. D.C. voltage to time conversion

A second amplifier, acting as a comparator, added to the circuit of Fig. 13.1 gives a system which may be used to produce a gate waveform of time period proportional to the magnitude of a d.c. voltage. The arrangement is illustrated in Fig. 15.1.

Positive reset pulses set the integrator output to approximately zero, and cause the comparator output to switch to its posi-

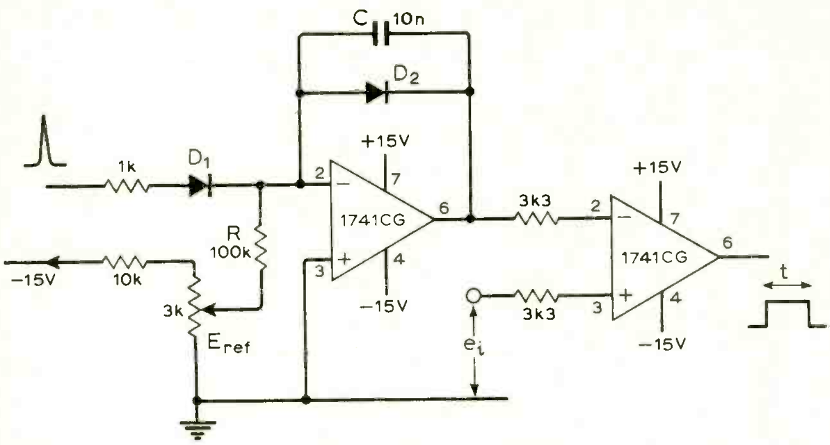



*Fig. 15.1 D.C. voltage to time conversion, achieved by adding a comparator to Fig. 13.1 circuit.*

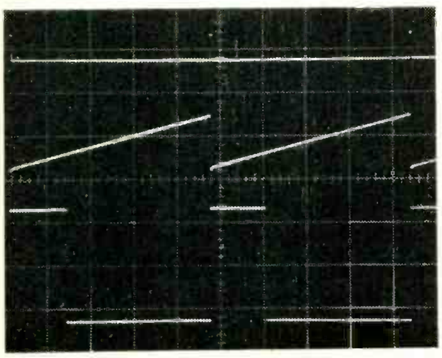


*Fig. 15.2 Action of Fig. 15.1 circuit. Top trace shows positive reset pulses; middle trace, integrator output; bottom trace, comparator output. Vertical scale, 10V/div.; horizontal scale, 2ms/div.*

tive level. At the end of a reset pulse the integrator output runs up linearly at a rate determined by $E_{ref}$ and the integrator time constant $CR$. The comparator senses when the integrator output reaches a voltage level which is equal to the input voltage applied to the non phase inverting input terminal of the comparator, and the comparator output then switches to its negative saturation level. The time period of the positive part of the comparator output waveform is proportional to the input voltage, and is determined by the relationship

$$t = \frac{CR}{E_{ref}} \cdot e_i$$

Typical waveforms which may be observed in order to examine the action of the circuit are shown in Fig. 15.2. Accuracy and linearity of conversion can be checked by measuring the time periods for a range of values of $e_i$.

Note that the time period is proportional to the ratio $e_i/E_{ref}$ so that if the reference voltage is replaced by a second input voltage the circuit then gives a time conversion proportional to the ratio of two input voltages.

In Fig. 15.1 the voltage $e_i$ must be positive; it must also, of course, be less than the integrator positive output voltage swing. A circuit which provides conversion of either positive or negative input signals can be made if the integrator output is applied to two comparators. One comparator is used to sense when the integrator output passes through zero, the other senses when it passes through a value equal to the input voltage. The time period between the transitions of the two comparators is then proportional to the magnitude of the input voltage. The sign of the input voltage is indicated by which comparator makes a transition first. Diode $D_2$ must be removed from the integrator to allow its output to be reset to a negative value. A system of this kind can be used as a basis for a simple ramp type d.v.m., the comparator transitions being used to generate start and stop pulses which are applied to a digital timer system.

# Raising transmitter valve dissipation

In transmitting valves the maximum dissipation power of smooth, thin-walled copper anodes is in the region of 120 W/cm² and this no longer meets present-day design requirements. The Swiss firm Brown Boveri has recently developed a valve with a light-weight anode which is capable of dissipating over 350W/cm². This figure has been achieved by combining a number of different surface structures in the anode.

Normally the anodes of vapour-cooled valves are provided with structures such as fins and corrugations. The main task of the fins is to provide heat transfer into the water as the anode load increases, while a vapour film forms between them. The maximum dissipation power of a valve with this type of anode can be varied through a wide range by changing its geometrical configuration (e.g. wall thickness, height of ribs, ratio of fin width to space between fins). The maximum dissipation power of light-weight structures with short fins and with a ratio of fin width to fin spacing of about 1:1 is in the region of 250W/cm². Brown Boveri made an attempt to raise this to over 300W/cm² by treatment of the anode surface in the gaps between the fins without having to use larger and bulkier fin configurations. Investigations were made into the effects of various small and micro-structures on the maximum dissipation power of a smooth, thin-walled copper anode. A transmitter triode with an output of up to 65kW was used as the specimen.

A rough surface increases heat transfer into the water because of improved bubble formation and higher bubble frequency. The maximum dissipation power also rises with increased surface roughness, so the dissipation was increased by 8 to 20% by means of sandblasting (depending on the grain size of the sand used). Highly porous surfaces can be produced by electrolytic plating processes. The maximum dissipation power of an anode plated with a 1mm thick layer of porous copper with an average pore diameter of several tenths of a millimetre was found to be 40% higher than that of a bare anode.

Investigations were also made of the long term behaviour of the maximum dissipation power of a valve, especially after a period of storage. A test was done on a tube with a sandblasted anode surface. Its maximum dissipation power was measured at intervals of several days during storage in normal atmosphere and was found to increase by about 20%. The increase is thought to be due to improved wetting, resulting from advanced oxidation at the copper surface.

The provision of fine structures of the order of millimetres at the anode surface also increases the maximum dissipation power in a similar fashion to micro-structures such as surface roughness or porosity. To investigate the effects of these fine structures, various cylindrical wire-mesh screens of different mesh sizes and wire thicknesses were fixed to the anode surface. A mesh configuration with a mesh width of 2mm enabled the maximum dissipation power to be raised by about 50% over anodes with smooth surfaces. The mesh was also fixed to the anode surface by a copper plating process to improve physical contact. With the anode surface thus prepared, and adding a porous copper layer, the maximum dissipation power was raised to 210W/cm². This is about twice that achieved with a bare anode and corresponds to the order of magnitude of the maximum dissipation power of finned anodes. A combined structure was made by fitting strips of wire mesh between the fins of a sandblasted double-fin anode and holding them in place by copper electroplating. The maximum dissipation power of this anode with an untreated smooth surface was 250W/cm² but, after the surface structure had been modified, this figure was found to have risen to 360W/cm².

# Letters to the Editor

*The Editor does not necessarily endorse opinions expressed by his correspondents*

## Frequency shift howl suppressor

I was interested in the description of the frequency shifter given by Dr Hartley Jones in the July issue of *Wireless World*, but there are a couple of points raised by the author with which I disagree.

Over the twelve years or so during which I have had occasion to use such a device I have not found any advantage in increasing the frequency shift by more than three hertz, two being often the optimum, and this has applied even in halls of moderate size. If more shift than this is employed the permissible degree of gain was not increased and the change in pitch in the reverberant sound was very obvious even on speech and quite unacceptable on music.

A further point is that the ear appears to accept a decreasing pitch fairly readily but regards an ascending one as definitely artificial and objectionable, even though the amount of shift is the same.

Finally, users should not always count on obtaining as great an improvement in gain as indicated, for with a well designed public address system I have found the possible gain increase when using a frequency shifter to be as low as 4dB. The use of the device does, however, considerably reduce the degree of coloration near howl-round.

H. D. Harwood,
B.B.C. Research Department,
Tadworth,
Surrey.

## Audio amplifier design

I have read the further letter from Mr Stuart of Lecson Audio in your August issue, and I am somewhat surprised that so much of conjecture or personal opinion should be stated by Mr Stuart as matters of established fact.

However, to take the main points on which Mr Stuart has thrown down the gauntlet:

*1. Transient intermodulation distortion*

It has been known by audio amplifier designers for very many years that unsatisfactory results were frequently obtained if the input bandwidth to the power amplifier was excessive, and more recently this has focused attention on the manner in which the amplifier responds to a transient input. A part of this problem was formerly analysed by Mr Otala in his paper presented in 1970, and he coined the above term for this problem.

I will try to summarize Mr Otala's argument with reference to the accompanying diagram.

If we take a feedback amplifier which consists of a chain of separate op-amp elements (for convenience I have shown three) of which, say, amplifier 3 is arranged to have the slowest response, and we apply a step-function input of sufficiently rapid rise time and sufficient magnitude, amplifier 1 will overload and produce severe intermodulation distortion in the transmitted signal, even when the magnitude of the input signal is within the normal input range of the amplifier, because the propagation delay of the main feedback loop is too long for the feedback to be effective in diminishing the magnitude of the applied signal — as seen by the first amplifier stage — during the transient condition.

This is a matter of practical concern in the design of transistor audio amplifiers, since the output transistors, represented by stage 3, will generally have a more sluggish response than the small signal voltage amplifier stages 1 and 2. Moreover, designers sometimes exacerbate this problem by choosing to stabilize the feedback loop by connecting a capacitor between the collector and base of the second voltage amplifier transistor, represented in my diagram by op-amp 2.

There are (at least) three solutions to this problem.

(a) To ensure that the propagation delay through the whole system is very low, in comparison with the signal bandwidth. This is the approach favoured by Mr Otala, but is expensive.

(b) To apply the loop stabilizing capacitor across stages 1 and 2, thereby ensuring that stage 1 does not run out of negative feedback under transient conditions. (This was what I referred to as a divided feedback loop.)

(c) To interpose an input bandwidth limiting circuit, which could well be in the pre-amplifier, to ensure that the rise time of the input signal does not exceed the handling capability of the amplifier.

I favour a combination of the last two methods and, in particular, I believe that the dissociation of the h.f. feedback capacitor from the amplifier output point helps to ensure that the amplifier is tolerant of unexpected reactive loads, even though one pays the price of a t.h.d. curve which worsens somewhat at the h.f. end. Since I also believe that it is better to put predictable tonal quality with unknown loudspeakers before refinement of paper spec. I remain content with this decision.

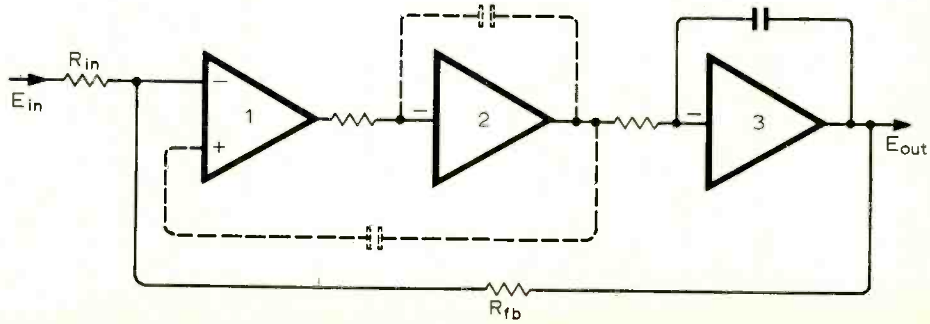
*2. Noise output from "virtual earth" amplifiers.*

Mr Stuart asks again how it should arise, if the "virtual earth" point appears to have a low noise impedance, that the noise output should rise when this is shunted by 47kΩ. Since Mr Stuart must know very well that the gain of a shunt feedback amplifier is determined by the ratio of the input and feedback limb impedances, and that, other things being equal the higher the gain the larger the noise output voltage, I had treated this as a rhetorical question.

Obviously, the "virtual earth" impedance is a notional thing which arises because of the feedback connection. Equally obviously, the gain of the system increases when the input limb is reduced from an impedance of infinity (o/c) to any lower value one chooses.

*3. Effective bandwidth of R.I.A.A. equalized stages.*

Mr Stuart says "of course the noise is calculated in a 20kHz bandwidth". May I suggest a simple experiment. If one takes a wideband feedback amplifier, of any input resistance value one likes, and measures the output noise with a 20kHz bandwidth, one will get a value which is in reasonable experimental agreement with the value predicted from



this bandwidth, the known gain of the circuit, and the thermal noise of the input elements. If now one connects across the feedback circuit the components necessary to provide the falling h.f. gain characteristic of the R.I.A.A. curve, the output noise will drop, simply because one has restricted the effective noise bandwidth. If this were not the case, the series feedback connection using an inductive input would be worse than it is.

J. L. Linsley Hood,
Taunton, Somerset.

## Inverter for fluorescent tubes

I should like to point out a serious error in the article "An efficient inverter for fluorescent tubes" by K. C. Johnson in your August edition.

Mr Johnson recommends preheating the fluorescent tube by switching 12 volts across the heaters. However, as I have proved to my cost, 12 volts is more than sufficient to initiate a discharge across the ends of the heater. Since the current drawn by this discharge is limited solely by the winding resistance of the chokes ( 1 Ω ), a current of several amps immediately flows, resulting in the sad demise of the tube heaters.

To overcome this problem it is necessary to limit the available current to the heaters, and two resistors of ten ohms interposed between the second terminal of the tube heaters and the double pole switch contacts will achieve this, without seriously limiting the warm up capability of the tube.

D. G. Chappell,
Twickenham,
Middlesex.

## V.A.T. and prices

Could I appeal to your advertisers to say either Including or Excluding V.A.T. ?

Those that do not make this clear cause unnecessary correspondence and create mistrust both by buyer and seller.

W. B. Henniker,
Henniker & Kerr,
Edinburgh.

## Printed circuits the easy way

Mr J. Ferguson's tips on making printed circuits (July Letters) are very useful. If readers try fibre or nylon tipped pens other than the "Miracle Pen" Mr Ferguson recommends they should etch some test pieces first.

Platignum "Penline Nylon Tip" and fibre tip "Magic Marker", indian ink and vitrina outline black, all easy to draw with, do *not* resist the ferric chloride. Another first rate pen designed for this purpose is the "Decon Dals", easy to use but a bit expensive.

The 30 or 40 minutes etching time can easily be filled in on other jobs, so that may not bother some people. It is important if using a flat dish to suspend the board copper side down in the etchant so that sediment falls away, and to slide the board in so as not to trap air bubbles. Small boards float without extra support.

I find this method good: the layout of components is planned using 0.1in squared paper. This is then transferred to typewriting paper, by pricking through the holes. On one side of the typewriting paper the components are drawn again and on the other side the printed circuit with any fibre tip pen. This might be repeated to rectify any errors or poor layout.

The laminated board is cut to shape and the copper cleaned. The paper pattern is cellotaped to the copper and the holes pricked into the copper surface with a cheap drawing compass. The paper removed, the holes are lightly centre punched, but not yet drilled. The circuit is now drawn on the copper with a suitable pen, and may be etched straightaway.

After etching and cleaning, the holes are quickly drilled with a Heathcraft Mini Drill which gives holes about 0.8mm, a suitable size for most component leads, though a few holes need a larger drill. Burrs can be removed by fine emery cloth to make soldering a trifle easier.

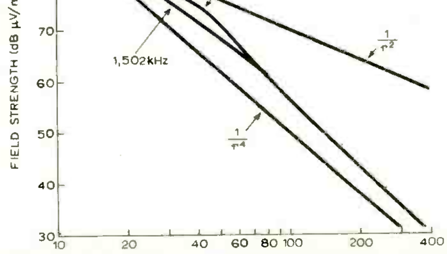
If any readers have not yet tried making these circuits I recommend them to try. With a little practice the finished result can give much more satisfaction than any other board construction method.

V. Rowe,
Salford.

## Radiating coaxial cables

I read with interest the suggestion of Mr Guy Moore that an aerial design which enhanced the radial vector component and suppressed the transverse component of the radiating field might provide a solution to the problem of frequency congestion and interference in the medium wave band. Such a design would indeed enable local broadcasting coverage to be provided without the associated long distance interference outside the service area.

Interest in frequency conservation is increasing every year and several methods of confining radiated signals have been investigated to date. One of the most promising solutions is the application of radiating coaxial cables, which not only confines the radiation to a defined area but has the added attraction of providing coverage in areas such as tunnels, mines and buildings which would be inaccessible by conventional methods.




Investigations into the operation of radiating cables in the absence of buildings or tunnel walls has yielded interesting results. Measurements were made on a length of radiating cable laid on the ground in an open area, and the results are shown in the graph. The cable was fed with a 1 watt source with the far end terminated in a matched load (50 ohms). The variation of field strength with perpendicular distance from the cable was then measured at the mid-point of the cable. At frequencies of 989kHz and 1502kHz the field variation was distinctly of an inverse $r^4$ nature. This was unaffected by either mounting the cable above the ground or burying it under the soil. The latter result is not surprising if in fact the radiation mechanism is a radial induction field and not a transverse electro-magnetic one.

Caution must be advised if this is attempted with a cable not designed to be buried, or one which radiates by electric field perturbation and not surface current transfer, as the presence of the moist earth will impede operation.

Working systems have been installed in a Scottish university and coverage was as predicted with no interference beyond the perimeter of the campus.

J. R. Avery,
Andrew Antenna Systems,
Lochgelly,
Fife.

## Magnetic units

Although "Cathode Ray" and I agree on most points, he raises some questions in the August issue (p.332) that require an answer. First, the P.M.A. still issues literature in both SI and c.g.s. units. Internally a few people use SI but I suspect the majority prefer c.g.s. Personally, I use whichever is more convenient in the circumstances. We are still probably a little ahead of the world in the use of SI; only last week I was sent a book on rare-earth-cobalt magnets to review. It was written by two distinguished members of Bell Telephone Laboratories and was entirely in c.g.s. units, apart from a conversion table. I think it is much fairer to compare the speed of conversion from c.g.s. to SI units in magnetism with the speed of decimalization as a whole rather than with the decimalization of money, which is a rather special case.

Secondly, the magnetization or polarization is not just of importance to physicists interested in fundamentals. Certainly one can design a loudspeaker magnet without knowing anything but the B versus H demagnetization curve of the magnetic material, but the new rare-earth-cobalt magnets have been developed largely because they are needed for t.w.ts in communication and other satellites. Two of these magnets can have almost identical curves between remanence and the normal B coercivity point, yet one may have double the intrinsic coercivity of the other. The intrinsic coercivity is the demagnetizing force that reduces the polarization *J* (magnetization *M*) to zero. The magnet with the higher intrinsic coercivity would perform satisfactorily, the other one would be seriously demagnetized by the conditions under which it would have to operate. An engineer who allows some equipment to fail because he thinks the intrinsic demagnetization curve only concerns fundamental physicists is not very competent; and if the equipment happens to be in a satellite he is unlikely to keep his job. Other devices which may contain magnets for which the intrinsic curve is important are car wiper motors and domestic electricity meters.

May I take this opportunity of correcting a typographical error in my article? In some of the labels of the axes on the figures an unnecessary bracket has appeared in an inappropriate place, so that the symbols for mega ampere per metre have been printed as $M(Am-^{1})$ instead of $MAm-^{1}$.

Incidentally, it is internationally agreed that symbols for physical quantities should be written in sloping (italic) type, but those for units in upright type. Thus magnetization in mega ampere per metre should be in symbols $M/\mathrm{MAm}-^{1}$. This convention has been followed in the text of my article, but not on the figures.

M. McCaig,
Permanent Magnet Association,
Sheffield.

## Reflex circuits

I have been roused out of hibernation by M. G. Scroggie's very interesting article on his 50 years of authorship (August issue). As he describes me as "ubiquitous", may I add a historical footnote to his statement that P. G. A. H. Voigt wrote "one of the first expositions of dual or reflex circuits in the first issue of *Modern Wireless* (which I founded on 9 January 1923 and edited).

In point of fact, this type of circuit in various forms had been "exposed" frequently during ten years before 1923. I had done much to publicize it myself long before its incorporation in popular set designs and before the paper I read before the British Association in 1923. For example, in my book "Thermionic Tubes in Radio Telegraphy and Telephony", issued by the publishers of *Wireless World* in 1921, I give three examples. In Fig. 117 appears the standard reflex circuit. In describing it, I state: "A single valve may be used not only to amplify the high-frequency oscillators but also to magnify at the same time the rectified pulses obtained from a crystal detector. Many variations of the Fig. 117 circuit may be devised." I referred to Telefunken's British Patent 8821 (15 April 1913) which contains a double-amplification (reflex) circuit. On p.166 I describe a reflex circuit with reaction and state: "A further development of the Fig. 128 circuit was to bring the detected current back into the grid circuit and so amplify it. This double-magnification circuit, which is exceedingly sensitive, is shown in Fig. 129." Later on I give in Fig. 205 a reflex circuit by Marius Latour. This is a reference to his British Patents 131092 (30 April 1917) and 132668 (17 Nov. 1917). The Marconi Company developed a ship's receiver using a reflex circuit with a single valve (the circuit appears in Fig. 124 of my book "Elementary Textbook on Wireless Vacuum Tubes" (published in 1922).

Over the formative years 1917 to 1920 *Wireless World* published thirteen of my articles on valve techniques. In Fig 14 of one entitled "The Valve as an Amplifier" appears a typical dual-amplification circuit with a full explanation. This issue is dated March 1918. I myself patented various forms of reflex circuit soon afterwards.

In view of the above selection of anticipations going back to 1913, I do not think that Voigt himself would have claimed in 1923 to have written "one of the first expositions".

May I take this opportunity of expressing the debt owed to Mr Scroggie by professionals and amateurs alike for his own brilliant and crystalline expositions which have enriched the literature of the subject for fifty years.

John Scott-Taggart,
Beaconsfield,
Bucks.

## Audio amplifier design

After reading the J. R. Stuart "Approach to audio amplifier design" (August issue), I was left gasping for oxygen as I absorbed the philosophy of the new generation of amplifier designers. How can Stuart continue with the normal, every-day mundane matters of life (shopping for cheap beef, shouting at the missus etc.) while knowing at the same time that his brain—or even the inner-being that is known as "self"—is all the time functioning as $f(P, s, t, \tau, m, D)$. I must admit though that there is comfort in the fact that distortion $D\%$ reduces according to cost $£Z$ in the manner $a \exp [Q.(D)^{-1}]+b.D^{-2}+c.D^{-1}$. I've memorized that for my next trip to the audio discount warehouse.

. . . but then I don't design amplifiers.

A. Bloomer,
Neasden.

## Quantities and qualities

I am gratified to note that W. B. Broughton (August issue, p.385) has troubled to search for an alternative to my suggested "forbiddivity" to replace the quantity name "reciprocal permittivity". In fact, his designation, "restrictivity", was amongst about a dozen possibilities that I considered — including such monstrosities as "constrainitivity" — but for some reason which now escapes me I was then under the impression that restrictivity was a term already used in some obscure branch of science. However, since restrictivity (or whatever) has the SI unit metre per farad, it could have been most appropriately named "elasticity" (being given dimensionally by elastance multiplied by distance) had not elastic been in practical use before capacitors. On closer examination of this naming problem, I now realize that my search for an *antonym* (not counterpart as suggested in August, since this is accepted as equivalent to synonym) was incorrect, the requirement being a *reciprocal*, which, until 1570, was taken to mean "inversely related". So, we are both off course, although I still regard forbid as an acceptable starting point, being synonymous with hinder and restrain; hardly indicators of absolute stoppage. Curiously, and as a precedent, the widely accepted reciprocal quantities impedance and admittance already exhibit an anomaly: does not "impede" suggest partial prevention whereas "admit" concedes total entry? At this juncture I may as well admit that all this discussion is merely a subtle manoeuvre to steer the SI authorities into giving the unit, metre per farad, the name baldock, symbol Ba!

In more serious vein and also referring to p.385, I am delighted that B. J. Shelley has drawn attention to the genius of Alan Dower Blumlein, since I tried to promote more widespread recognition by creating the B.K.S.T.S. memorial meeting concerning Blumlein's work that took place on May 1st 1968. For years — perhaps I should say decades — Mr Scroggie has been insisting that the "Miller integrator" should rightfully be called the "Blumlein integrator", and, apart from Blumlein's diverse and fundamental contributions to stereo techniques and 405 line TV developments, few electronic engineers know that he invented the transformer ratio arm bridge (Sept. 1928), the cathode follower (Sept. 1934; the forerunner of the emitter follower for those not brought up on thermionic devices) and the long-tailed pair (July 1936), to name just a few of the 128 patents in which his name appears, and the result of developments over only 15 years prior to his untimely accidental death in June 1942.

An insight into Blumlein's humility is revealed by his attitude to research and development. I know several pioneers who worked closely with him at E.M.I. on television in the mid 1930s and have heard many interesting anecdotes. For instance, when A.D.B. could not help the team directly under "panic" breakdown conditions he was not above making the tea!

The full story of Alan Blumlein's contribution to technical history will appear in the forthcoming biography by Mr F. P. Thompson, written in conjunction with Simon Blumlein, and anyone with information likely to be of value should write to Mr Thompson at 39, Church Road, Watford WD1 3PY, Herts, England.

R. N. Baldock,
Harrow,
Middlesex.

# Literature Received

*For further information on any item include the WW number on the reader reply card*

## ACTIVE DEVICES

Wall-charts (in striking variations on a theme of puce) have been produced setting out salient performance details of c.m.o.s. logic devices and germanium power transistors by Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx. .......... WW401

A range of studio recording equipment, including a modular system, reverberation equipment, signal processing equipment and a phase meter, is briefly described in a leaflet produced by Allen and Heath Ltd, Pembroke House, Campsbourne Road, Hornsey, London W.8. .......... WW402

A wall chart giving salient performance figures of a selection of linear integrated circuits, including operational amplifiers, comparators and regulators has been sent to us by National Semiconductors (U.K.) Ltd, The Precinct, Broxbourne, Herts EN10 7HY. .......... WW403

The design of logic systems using the 74 series of integrated circuits is well covered in TI's new publication "System 74". It offers advice on the loading and compatibility of the different groups of devices in the 74 family. Applications of t.t.l. and the problems of interfacing with other equipment are discussed and there is a section on memories. Texas Instruments Ltd, Manton Lane, Bedford .......... WW404

The Lock Distribution Electronic Components catalogue contains information on products from Motorola, Signetics, Thomson CSF, Dow Corning, Waycom and Electrosil and gives details of technical publications available and distribution centres of Lock Distribution, Neville Street, Middleton Road, Oldham OL9 6LF, Lancs. .......... WW405

The 1973 Erie catalogue of electronic components incorporates the export and distributor stock catalogues. Components listed range from resistors and capacitors to thick film devices and semiconductors. Erie Electronics Ltd, South Denes, Great Yarmouth, Norfolk. .......... WW406

We have recieved a leaflet on m.n.os. electrically reprogrammable memory elements, describing characteristics, mode of operation, typical circuits and future developments from General Electric Semiconductors Ltd, East Lane, Wembley, Middx. HA9 7PP. .......... WW407

A catalogue listing semiconductors, including i.cs, memories, m.o.s. devices, f.e.ts and photo-electric devices, made by Fairchild, Mullard, Plessey and Lucas, has been produced by Gothic Electronic Components, Beacon House, Hampton Street, Birmingham 19. .......... WW408

## PASSIVE DEVICES

Resistors and capacitors and their more important performance characteristics are shown in tabular form on a large new wall-chart, sent to us by the Instrumentation and Control Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. .......... WW410

A catalogue covering a wide range of passive components including terminals, coils and formers, capacitors, connectors and other small hardware is available from Cambion Electronic Products Ltd, Castleton, Nr. Sheffield, S30 2WR... WW411

We have received a short-form catalogue, describing collet knobs, relays, rotary and thumbwheel switches and many other passive components from Radiatron Components Ltd, 76 Crown Road, Twickenham, Middx. .......... WW412

A catalogue describing eleven types of Melesco thermocouples, which contains a guide to the use of these devices and recommendations on maximum temperatures is available from International Combustion Ltd, Ashburton Road East, Trafford Park Industrial Estate, Manchester M17 1LA... WW413

A leaflet covering several ranges of miniature, rotary stud switches has been received from Highland Electronics Ltd, 33-41 Dallington Street, London EC1V 0BD. .......... WW414

A catalogue detailing the Pohl range of cable clamps has been sent to us by C.T.L. Components Ltd, 223/243 Wimbledon Park Road, London S.W.18. .......... WW415

A buyer's guide to the U.K. capacitor market, containing information on which types of capacitor are handled by over 100 firms, has been published by Eurolec, Little Waltham, Chelmsford CM3 3NU. Price 95p by post.

## EQUIPMENT

Mobile microwave links TFH-TM210A (7GHz) and TM213 (13GHz), are described in a leaflet supplied by Thomson-CSF, Division Radiodiffusion Television, 100 Rue du Fosse Blanc, BP49, 92230 Gennevilliers, France. Specifications of the video and audio channels, multiplex telephony and power supply are included. .......... WW416

Crystal oscillators — miniature, oven controlled, high stability and temperature compensated — crystal controlled clocks and a rubidium frequency standard are among products described in a leaflet from Oscilloquartz SA, CH-2002 Neuchatel 2/Suisse .......... WW417

Radiatron Ltd, 76 Crown Road, Twickenham, Middlesex TW1 3ET, has issued a four-page leaflet describing the range of mechanical, analogue and digital tachometer equipment that they market in the U.K. on behalf of Jaquet AG, Switzerland .......... WW418

The latest Servoscribe flatbed recorder range, which are $200\mu$ V to 250V d.c. deflection instruments with a writing width of 200mm, using rolls or single sheets, is described in a leaflet available from Smith Industries, Ltd, Industrial Equipment Division, Waterloo Road, Cricklewood, London NW2 7UR .......... WW419

Colour picture monitors made by NV Cobar Barco, of Kortrijk, Belgium are described in three brochures available from the U.K. agents Crow of Reading Ltd, 79 London Street, Reading, Berks RG4 QDX. Each of the three types (of modular construction for ease of servicing) display RGB signals and PAL, Secam or NTSC-coded composite signals using the appropriate plug-in chrominance demodulator. The last two digits in the type number indicate the screen size in cm.

CTVM2/38 .......... R W420
CTVM2/51 .......... WW421
CTVM2/66 .......... WW422

A single page date sheet for the DN-70 liquid nitrogen cooling unit is available from Oxford Instruments, Osney Mead, Oxford, OX2 0DX .......... WW423

"Cossor SSR Systems" is a booklet describing different types of secondary surveillance radar systems and fundamental performance requirements. Cossor Electronics Ltd, The Pinnacles, Harlow, Essex. .......... WW424

A catalogue of electronic kits covers the subjects of audio, radio, laboratory and automotove equipment and also contains general product information including calculators, metal locators, intercoms. Heath/ Schlumberger, Advertising/PR Services, Bristol Road, Gloucester GL2 6EE. .......... WW425

A full range of high-fidelity sound reproduction equipment including tuner-amplifiers, amplifiers, turntables, speakers, mixers, etc., is described in a catalogue sent to us by Eagle International, Heather Park Drive, Wembley HAO 1SU.WW426

We have received a leaflet giving full technical information on the Response BM 104 10-channel studio mixer from Audio Applications Ltd, Kensington Barracks, Kensington Church Street, London W8 4EP .......... WW427

A new catalogue covering their range of electronic measuring instruments has been published by Keithley Instruments Ltd, 1 Boulton Road, Reading RG2 0NL. .......... WW428

A leaflet describing photon counting systems for use in signal recovery from quantum detectors such as photomultipliers has been produced by Brookdeal Electronics Ltd, Market Street, Bracknell, RG12 1JU. .......... WW429

A leaflet describing display and recording accessories for use with the Datalab 900 series of transient recorders is available from Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey CR4 4HR. .......... WW430

## GENERAL INFORMATION

A revised catalogue of Puratronic ultra-pure chemicals and metals used in the manufacture of electronic materials and devices has been sent to us by the Publicity Department, The Johnson Matthey Group, 78 Hatton Garden, London EC1P 1AE. .......... WW431

We have received two publications from the British Standards Institute, 101 Pentonville Road, London N1 9ND.

"Electronic tube terminology" — group 06 of Part 1 of the glossary of terms common to electrotechnology. .......... Price £2.00

Code of Practice for the reception of sound and television broadcasting — CP1020 : 1973 .......... Price £2.00

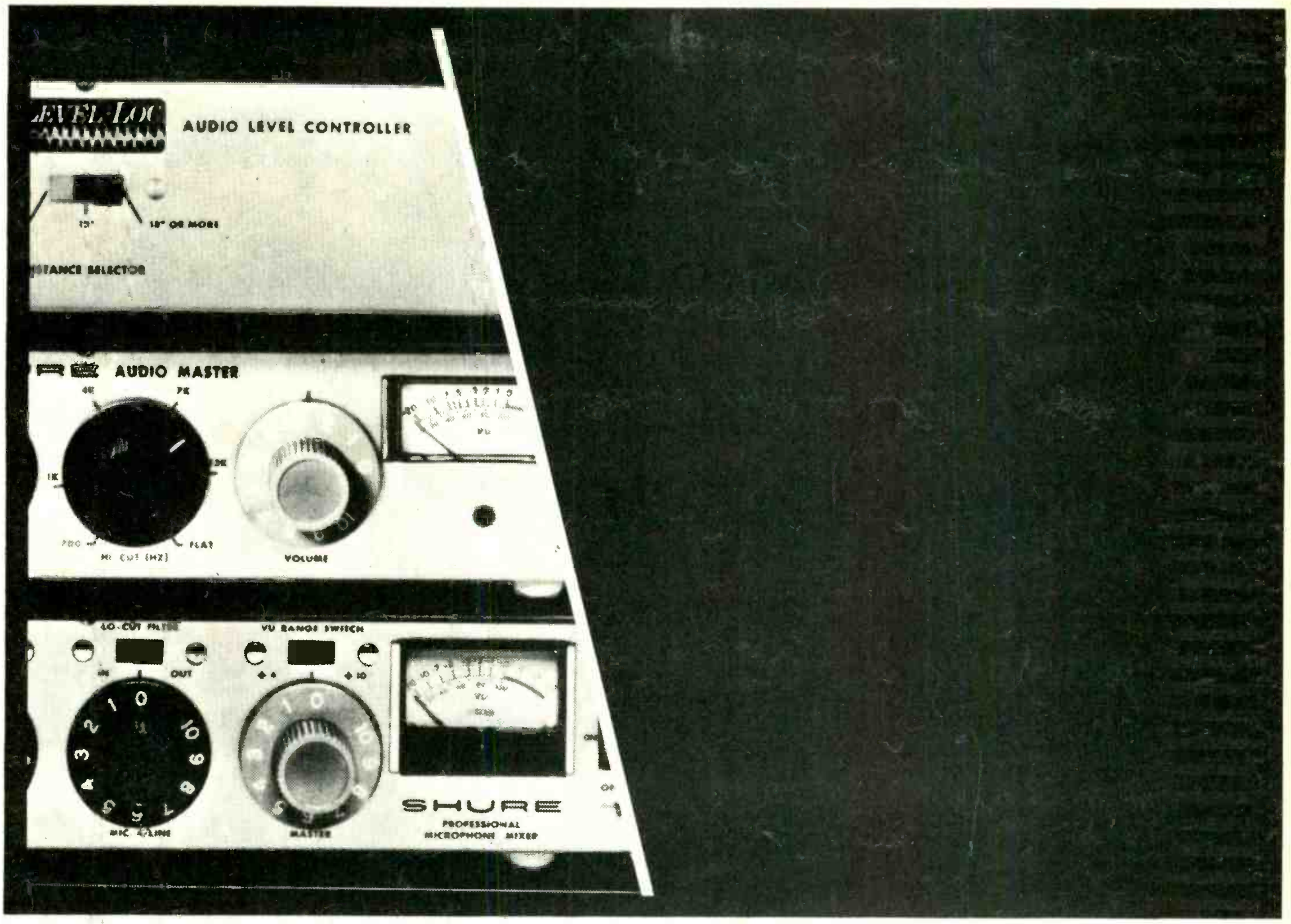
A guide to the quality and reliability testing of resistors and capacitors, including a brief description of BS9000 and its relation to the C.E.C.C. system, has been received from the Instrumentation and Control Electronics Division, Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HD. .......... WW432

We have recently received a catalogue describing servicing instruments, tools and materials intended for the installation and maintenance of domestic equipment from Rank Radio International, Drayton Road, Borehamwood, Herts. .......... WW433

Recently produced by Jermyn is a catalogue supplement describing a large variety of both active and passive components and assemblies, for which the firm is a distributor. Other services described include coil winding, component matching and sub-assembly work. The supplement can be obtained from Jermyn Distribution, Vestry Estate, Sevenoaks, Kent. .......... WW434

We have received a catalogue containing information on calculators, large-scale i.c. chips for clocks and a receiver circuit, display devices and other components from Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts. .......... WW435

We have received a leaflet listing books written for postgraduates studying electronics and published by Butterworth & Co. Ltd., 88 Kingsway, London WC2B 6AB. .......... WW436

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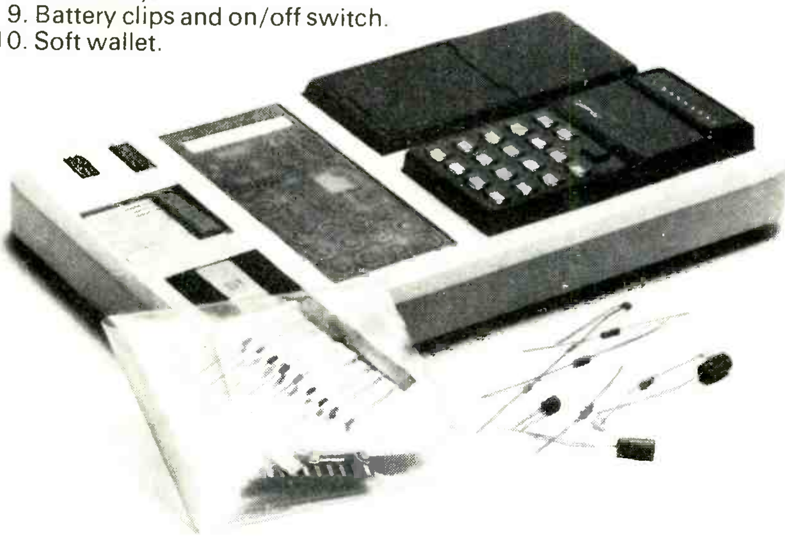

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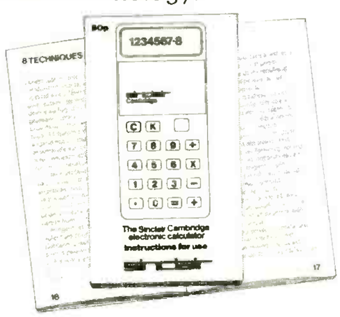


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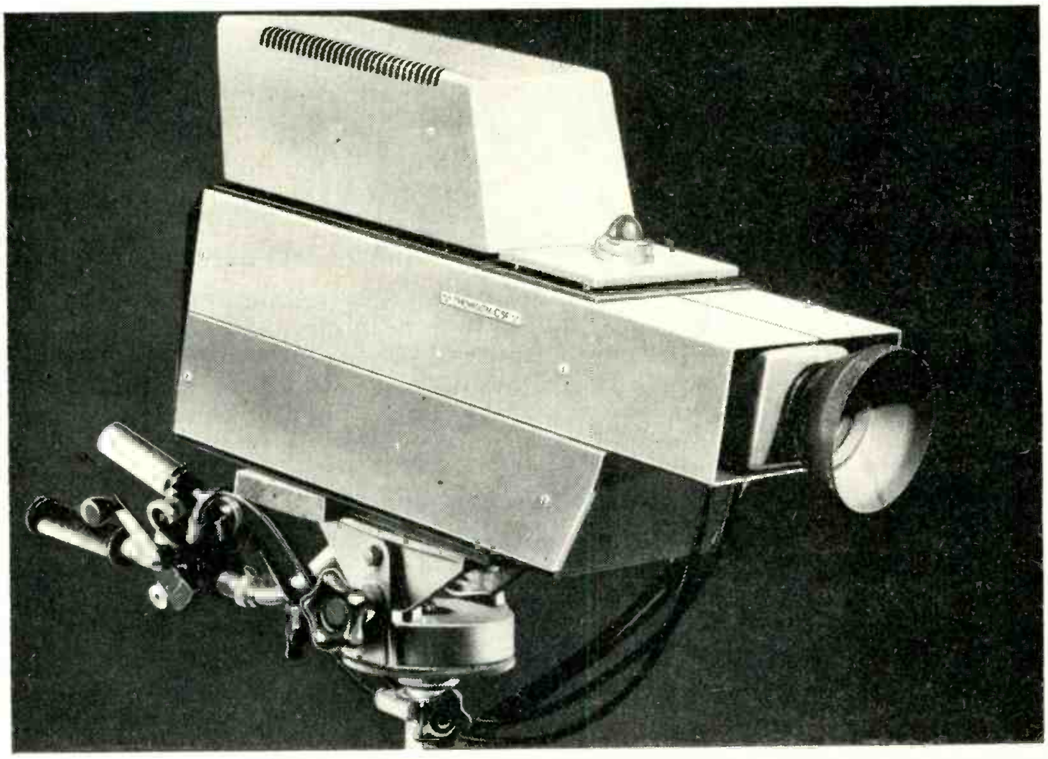

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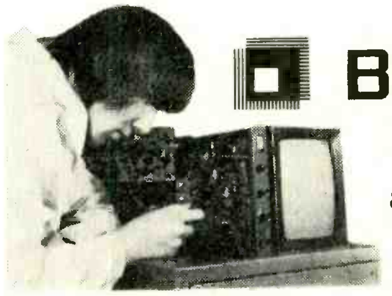

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# Single Sideband, Suppressed Carrier Generation

## Modification of the "third method", made possible by the use of integrated circuits

*by A. J. Turner* M.Sc.,G3UFP*

Two distinct methods of generating a single sideband signal have found widespread use. These are known as the filter method and the phasing method. A third method has been described[1] but this has not found much favour. The purpose of this article is to try to resurrect some interest in the third method and present a new alternative made available by integrated circuits.

The principle of the filter method is shown in Fig. 1. The baseband signal is converted to a double sideband signal at an intermediate frequency, usually in the range 1-10MHz. A highly selective filter, usually quartz crystal or mechanical, is used to obtain a single sideband which is translated on to the transmission frequency by one or more stages of heterodyning using balanced modulators.

A block diagram of the phasing method is shown in Fig.2. The baseband signal is applied to a wide-band phase shift network. The output from this and the unshifted signal are applied to a pair of balanced modulators. The translating carrier is also split into two quadrature components. When the output of the two balanced modulators are added, one set of sidebands add whilst the others cancel, leaving an s.s.b. signal.

### Third method

A block diagram of this method is shown in Fig. 3 from which it can be seen that this method comprises both filtering and phasing techniques.

The third method offers the following advantages over the others: highly selective filters, which introduce a loss of quality, are not needed, nor are wideband phase shift networks which require careful design and very accurate component values if adequate sideband suppression is to be achieved. In addition, imperfections in filtering and phasing or in balanced modulators do not result in unwanted sidebands *outside* the bandwidth of the wanted sideband. This is important when channel conservation is an important reason for using a single sideband system. Before considering the suggested modification to the third method, a brief description of the principle of the original system is necessary.

Suppose the baseband input signal is speech which has frequency components between 300Hz and 3300Hz and the pilot frequency is 1800Hz. Each output of the first pair of balanced modulators then consists of two sidebands of translated speech, the upper between 2100Hz and 5100Hz and the lower between 0Hz and 1500Hz. The low pass filters, whose transition region is between 1500Hz and 2100Hz where there is no energy, remove the upper sideband. The outputs from the second pair of balanced modulators each consists of an upper and lower sideband displaced about the translating carrier frequency. The two upper sidebands are in anti-phase.[1] The required single sideband may be obtained by adding or

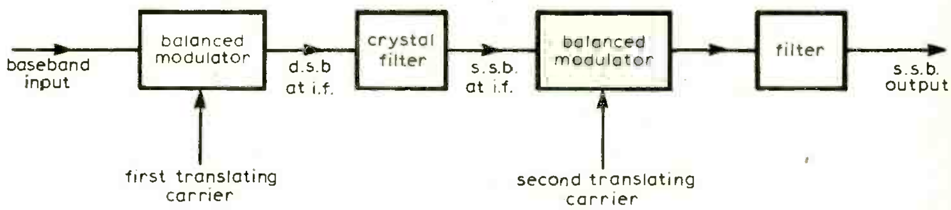



*Fig. 1. Filter method for the generation of an s.s.b. signal.*

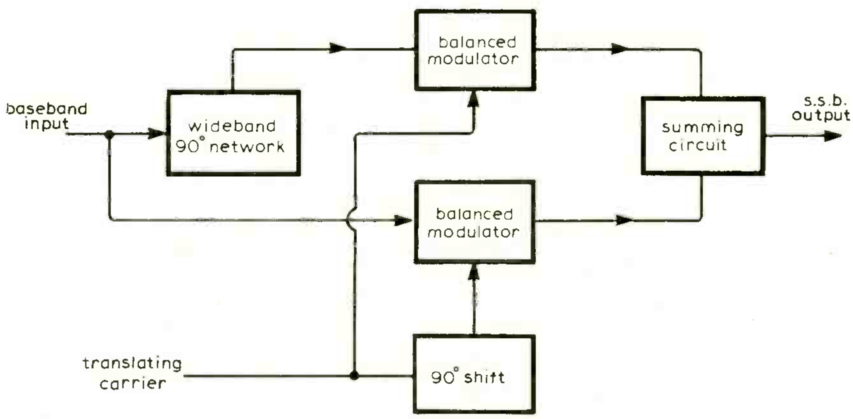



*Fig. 2. Block diagram of the phasing method for s.s.b. signal generation.*

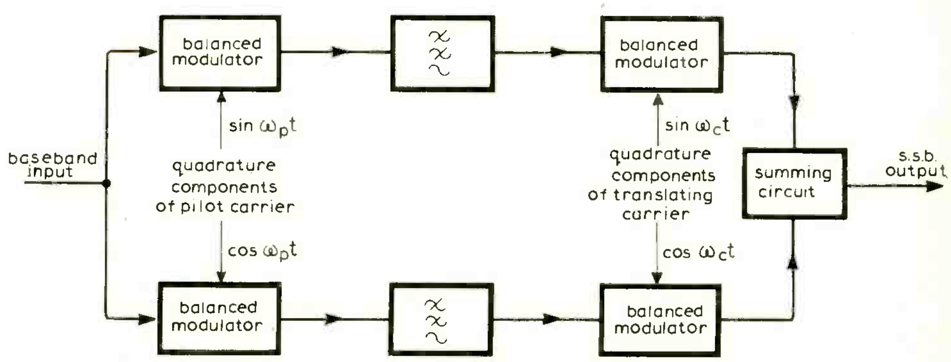



*Fig. 3. Block diagram of the third method of s.s.b. signal generation, which involves both filtering and phasing techniques.*

* Hatfield Polytechnic

subtracting the outputs of the second balanced modulators.

### Modified third method

The disadvantage with the third method is that both the pilot and translating frequency carriers must be accurately split into quadrature components. This is not too difficult to accomplish at the low frequency of the pilot carrier. However, in order to minimize the number of stages of frequency translation after the exciter, the translating input to the second balanced modulators must be at as high a frequency as possible. Ideally, it should be the desired transmission frequency. Generation of high frequency quadrature signals is usually accomplished by loosely coupled tuned circuits and at 1MHz this requires critical adjustment and layout of the circuit. The problem is worse at 10MHz and almost impossible at 100MHz. This problem may be overcome with the aid of digital integrated circuit techniques. Suppose we take a sine-wave oscillator whose frequency is four times that of the desired frequency of the translating input of the second balanced modulators. A conventional squaring circuit and RC differentiator may then be used to convert this to a positive going pulse train at the same frequency, as shown in Fig.4. Provided that the amplitude of the spikes is greater than about 3.5V this signal may be applied to the clock input of the circuit in Fig.5.

This is essentially a divide-by-four using two JK flip-flops. Its action may be understood from the following truth-table remembering that the flip-flops are "cross-coupled" so that $J \neq K$ and $J_1 = X_2$ whereas $J_2 = X_1$. The $X$ output follows $J$ on the next clock pulse.

| Number of clock pulses | flip-flop 1. $J_1$ | $X_1$ | flip-flop 2. $J_2$ | $X_2$ |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 1 |
| 3 | 0 | 1 | 0 | 0 |
| 4 | 0 | 0 | 1 | 0 |
| 5 | 1 | 0 | 1 | 1 |
| 6 | 1 | 1 | 0 | 1 |
| 7 | 0 | 1 | 0 | 0 |
| 8 etc. | 0 | 0 | 1 | 0 |

It can be seen from the above table that the $X$ outputs are square-waves whose frequency is one quarter of the clock frequency. Moreover the output $X_2$ is delayed by one clock pulse compared with $X_1$, so that the outputs form quadrature square waves. It is not necessary to convert these square-waves to sine-waves before application to the balanced modulators, indeed this would be difficult to do without introducing phase errors.

The reason for this is that a square-wave has energy at the fundamental frequency and odd harmonics only. So in the case of the first balanced modulators, the use of quadrature square-waves for the pilot carrier produces an ouput having sidebands between 0 and 1500Hz and between 2100 and 5100Hz as before. High frequency sidebands about odd multiples of the pilot frequency will also be produced, but these will be eliminated by the low-pass filters.

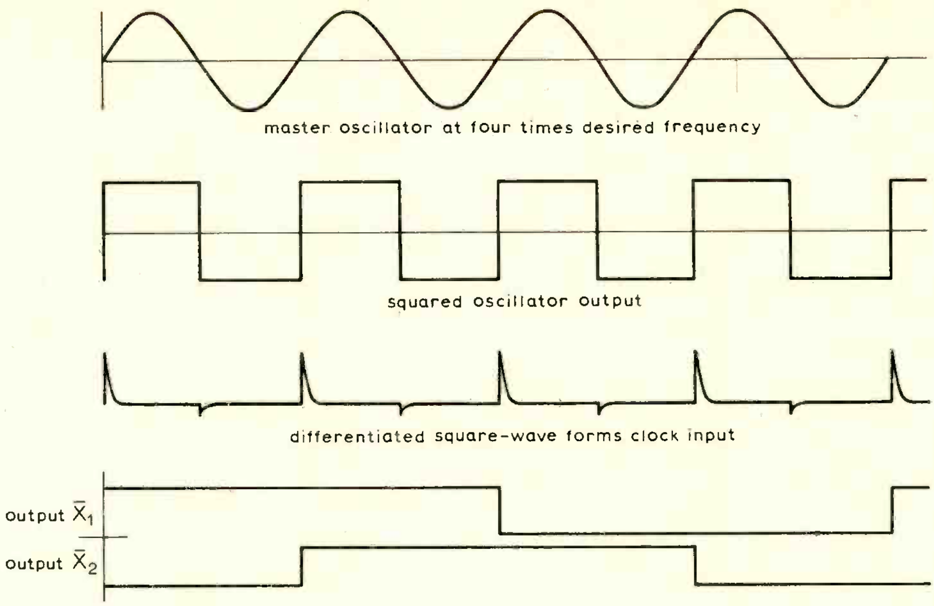



*Fig. 4. Stages in the production of quadrature square-waves.*

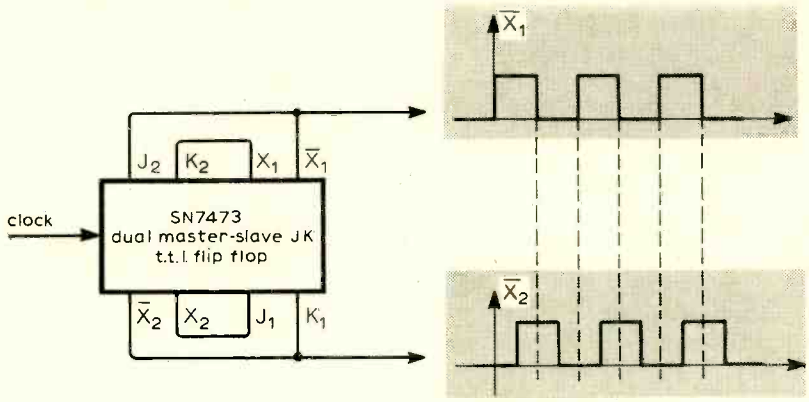



*Fig. 5. Use of a t.t.l. i.c. to obtain quadrature square-waves.*

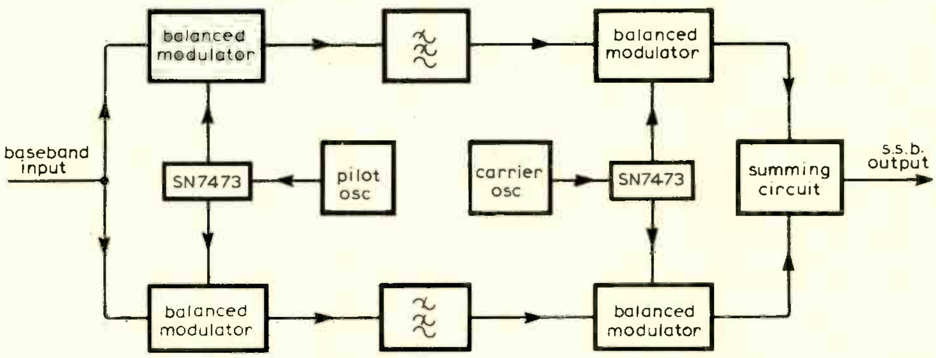



*Fig. 6. Block diagram of the modified third method of s.s.b. signal generation.*

Quadrature square-waves, this time at a high frequency, may also be used for injection to the second balanced modulators so that a complete exciter may be made as shown in Fig.6. In practice, the modulator outputs are added using a tuned circuit and the exciter output is subsequently filtered and amplified before radiation. This filtering will remove high frequency components generated by the use of square-wave translating carriers.

However, there is a hidden advantage in using square-waves. As shown in Fig.7 the harmonic components of the quadrature square-waves also form quadrature pairs. This means that the summing tank circuit may be tuned to a harmonic of the square-wave input and a true single sideband signal at that frequency will be obtained. This enables a higher transmission frequency to be reached without subsequent stages of translation.

The circuit of Fig.5 has been found to accept a clock-input of at least 4MHz and produce square-waves at 1MHz. By tuning to 3MHz or 5MHz higher frequency output is obtained. The use of higher harmonics is limited by their reduced amplitude. How-

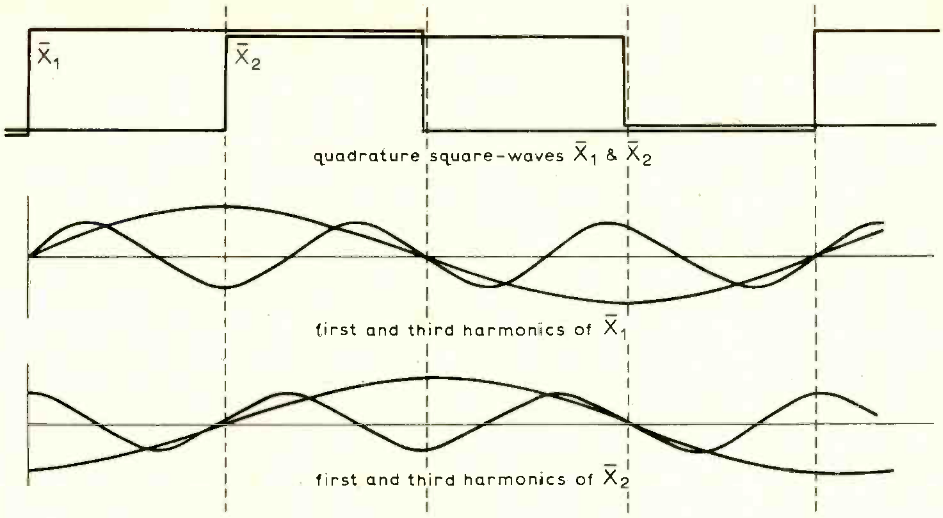



*Fig. 7. Harmonic components of the quadrature square-waves, which also form quadrature pairs.*

ever, the 7473 referred to in Fig.5 is a slow device; even the 7472 edge-triggered flip-flop can offer a 50% increase in clock frequency.

The author is currently developing an exciter based on these principles using very high speed Shottky logic capable of accepting a 100MHz clock input and producing s.s.b. on 25MHz with no stages of translation after the exciter. It is hoped that by using the third harmonic, s.s.b. on frequencies as high as 500MHz may be produced with only one stage of translation after the exciter. Since the accurate tuning of circuits to obtain the quadrature signals is not required the output frequency may be varied by tuning the oscillator, no other tuning being necessary over a fairly large range of frequencies.

## Conclusion

The modified third method, using quadrature square-waves for the translating and pilot carrier, offers all the advantages of the conventional third method. In addition, since it requires no adjustment and no inductors, except those in the filter and oscillators, and since the quadrature components are inherently accurate, its performance should be superior in terms of sideband suppression and reliability.

The use of harmonics can extend the frequency range that can be covered and minimizes the number of translation stages.

Integrated circuits have their effect on the balanced modulators also. The device SN56/76514 is a balanced modulator offering conversion gain which should enable a complete exciter using only six integrated circuits and two transistors for the oscillators to be built.

**Reference**

1. Weaver, D.K., "A third method for the generation and detection of single sideband signals," *Proc. I.R.E.* 1956 Vol. 44, Part 12, pp1703-1705.

# New electrochromic display

A new type of display device which produces a purple display on application of electric charge has been developed at Philips Research Laboratories at Eindhoven. Displays using the principle — for which patents have recently been granted to Philips — offer long-term memory, low switching voltage and good contrast that is independent of viewing angle. Previous electrochromic displays, like those based on electro-plating, colour changes in pH indicators or metal oxide colour centres, have suffered from high power consumption, irreversibility and/or low speed.

The Philips display is based on a redox (oxidation-reduction) reaction of diheptylviologendibromide in water. This colourless organic compound can be reduced at a cell cathode on application of a p.d. greater than the redox potential into a purple radical ion that reacts with the bromine anion to form a compound insoluble in water that precipitates onto the cathode. Exceeding the redox potential reduces the viologen dye ion further to form an unstable product which immediately reacts with the original ions to form the purple ion. The cathode deposit remains until the cell is reversed.

This is done by short-circuiting the electrodes (which is very slow at around 0.5s) or by applying the opposite polarity, giving an erasure time of 10 to 50ms. This simple way has a snag in that build-up can occur on the anode, effectively slowing the cell down on subsequent cycles. A solution is to use a third, reference, electrode — formed in the case of seven-bar displays by the two islands in a figure eight. This is placed in a feedback circuit in such a way that cell current is controlled so that the p.d. between reference electrode and cathode becomes zero. With this potentiostatic technique, which needs only a simple differential amplifier, current only flows when a coloured layer is on the cathode.

For a reflectance of 20%, writing time is about 15ms for a cell voltage of between $1 \pm 0.4$V. This value of reflectance is obtained with a charge density of 2mC/cm$^2$, equivalent to about 100mW in the display we saw. Contrast ratio was 5:1, which could be increased by passing more charge, being quite independent of viewing angle. Typically, 1mJ of energy is required for a seven-bar numeral of $5 \times 10$mm, with no energy requirement during storage. The low switching power at low voltage makes such a display compatible with t.t.l., and i.g.f.e.t. (m.o.s.) technology.

Electrodes can be made of a metal or of the conducting, transparent oxides of tin or indium and deposited onto a glass plate. A second glass plate spaced 2mm from the front plate forms the cell, which is filled with an aqueous solution of the organic compound together with potassium bromide to increase conductivity. The cell needs to be hermetically sealed, oxygen leakage limiting storage life. Cells have been run over $10^5$ cycles so far and the coloured ion shows no degradation after a year.

This organic cell shows a higher figure-of-merit (contrast/charge) than a similar, inorganic, electrochromic display using tungsten oxide, and being developed elsewhere, by a factor of 3 to 5.

# World of Amateur Radio

## Citizens to gain amateur frequencies?

A recent announcement by the American F.C.C. proposes that the frequency band 224 to 225 MHz (which at present forms part of the 220 to 225 MHz amateur band in Region 2) should be re-allocated to a new Class E Citizens' Radio Service. The new band would be divided into 40 channels each 25 kHz wide. In its combined inquiry and rulemaking notice the F.C.C. invites comments on these proposals by September 20 and states that it will reply to these by October 22; unless there are unexpected delays American manufacturers are expecting that the new Citizens' Band will be in operation next year, although F.C.C. states that it will establish enforcement procedures before any use of the band is permitted.

This move follows a long campaign by American firms and some users of the 27 MHz Citizens' Band to obtain more frequencies. The original C.B. facilities, introduced in 1945, were limited to u.h.f. and attracted little attention. But with the introduction of the 27 MHz allocation in the United States in 1958 the numbers began to grow rapidly; from about 49,000 in 1959 to 868,013 in 1971, though in this expansion many abuses of the facilities became apparent in what had originally been intended as a short-distance radiocommunications service for fixed or mobile operation.

The new band, if implemented, is likely to further increase the antipathy of many amateurs towards Citizens' Band operation They can point to the I.T.U. Radio Regulations which allocate, in Region 2, the entire 220 to 225 MHz to amateur and radiolocation services on an equal basis; the F.C.C. proposal to assign part of this to a non-amateur radiocommunication service would thus appear to be in breach of the international regulations. European amateurs are not directly affected since this band is not available to amateurs in Region 1 but they will be concerned to note a further loss of frequencies by the amateur service.

## 25 years on "Two"

On September 1, 1948 part of the 144 to 146 MHz ("Two metre") band was released to amateurs in the U.K. for the first time as a result of the new frequency allocations made at the ITU Atlantic City conference in 1947. Within a few weeks, despite the temporary power restriction to 25 watts, contacts were being made by a small band of enthusiasts (most of whom had gained v.h.f. experience on the old 56 MHz band) with stations in Western Europe. For example Denis Heightman, G6DH at Clacton, made the first contacts with Holland, France and Belgium and one of the earliest long-distance contacts was between G5BY at Bolt Tail, South Devon and PAOPN in the west of Walcheran, Holland.

Since then this has become in the U.K. perhaps the most used of all amateur bands, with literally thousands of stations operating in almost all modes, including a.m., n.b.f.m., s.s.b., a.f.s.k. and slow-scan television. Contacts over distances of roughly 300 to 400 miles are accepted as being likely to occur during almost any period of concentrated activity, such as the many contests held on the band. The longest span ever covered on the band — 2540 miles between California and Hawaii — was almost certainly achieved by tropospheric ducting, and this propagation mode may have accounted for the contact between Australia and New Zealand in 1965. In Europe, a day still remembered was July 4, 1965 when one of the rare Sporadic E openings on this band resulted in many contacts with Yugoslavia, Hungary and even Rumania; The European record of 1387 miles was made on that day during a contact between Eire and Yugoslavia. The increase in Sporadic E openings on 70 MHz this year as we again approach a sunspot minimum suggests that further openings on 144 MHz may occur during the next few years.

## Courses for potential amateurs

In September and October many courses covering the syllabus of the Radio Amateurs' Examination will be starting at various technical colleges, adult education centres and the like with a view to preparing students for the examination next May. A partial list of centres (based on information from the organizers or from the R.S.G.B.) is given below, but in other places it may prove worth enquiring locally since the list is unlikely to be complete.

**London and Home Counties:** Beckenham, Kent (Adult Education Centre); Chertsey, Surrey (Institute of Further Education); Cove, Hampshire (N. & W. Farnborough Further Education Centre) also Morse; High Wycombe, Bucks (College of Technology); Holloway, London (Shelburne Youth Centre); Slough (College of Technology) also an "advanced" course for those who already have an amateur licence; Welwyn Garden City (Mid-Herts College of Further Education); Weybridge, Surrey (Brooklands Technical College).

**Provinces:** Bath, Somerset (City of Bath Technical College); Boston, Lincs (College of Further Education); Bridgnorth, Shropshire (College of Further Education) also Morse; Cannock, Staffs (Cannock Chase Technical College); Cheltenham, Glos. (North Gloucestershire College of Technology); Doncaster, Yorks (College of Technology); Knaresborough, Yorks (Adult Education Centre); Lichfield, Staffs Lichfield School of Art and Evening Institute); Liverpool (Riversdale College of Technology); Peterborough, Hunts (Technical College); Sheffield, Yorks (King Edward VI School); Stafford (College of Further Education) and Morse.

## National Field Day

Preliminary results — still subject to confirmation — of this year's National Field Day put the Surrey Radio Contact Club as overall winner, with Oxford & District Amateur Radio Club runner-up; Glenrothes club was third and also winner of the Scottish N.F.D. In the single-entry stations the B.B.C. club "Ariel Radio Group" (Langham) was top scorer with East Barnet as runner-up.

## In brief

Ron Wilkinson, VK3AKC of Geelong, Victoria recently became the first Australian amateur to contact the United States through moonbounce on 1296 MHz. He used a 20ft diameter parabolic dish aerial which he and his wife built and tested in six months . . . Hilary Mathews, grand-daughter of the late John Clarricoats, G6CL, has been licensed as G8HCG. Her father, Peter Mathews is G3BPM . . . . West German amateurs can now use 1815 to 1835 kHz (s.s.b. operation confined to top 3 kHz) . . . . The M.P.T. has agreed to renew the experimental licence for the 144 MHz repeater station GB3PI for a further twelve months . . . . A group of Australian amateurs recently recovered and tested an early Command (SCR283) airborne installation which had remained for over 30 years in tropical jungle in an Airacobra fighter plane that force-landed in 1942. The t.r.f. receiver was still in working order and the transmitter required only the replacement of block capacitors; the entire equipment has since been fully restored . . . . A south-east counties h.f. convention is to be held at the Airport Hotel, Crawley, on Sunday, November 18 . . . . A second Amateur Radio Retailers Association exhibition is to be held at Granby Halls, Leicester on October 25 to 27 . . . . A mobile rally is being held at the Nettleswell Comprehensive School, Harlow on Sunday, September 23.

PAT HAWKER, G3VA

# Multi-channel Tone Control

## A five-channel unit using active band-pass filters

*by J. R. Emmett*, B.Sc.*

New ideas in tone controls have appeared in the last few years[2,3] which improve or supplement bass and treble controls, which are usually of the Baxandall type.[1] If the function of these controls is clearly understood, a fairly flexible amplitude frequency response curve can be built up. However, an easier and more versatile method of building a desired response is to use a number of overlapping, variable gain, frequency channels, spaced evenly throughout the audio spectrum. By using linear slider potentiometers, the control panel presentation can be made to resemble a response against frequency graph. In this form the system is sometimes called a "graphic equalizer". The unit which will be described for construction has five channels with centre frequencies of 50Hz, 200Hz, 800Hz, 3.2kHz and 12.8kHz. The linear slider potentiometers used give a control range of $\pm$12dB. The designed signal level for normal use is around 0dBm (approximately 800mV), a level matching most modern amplifier and recording equipment inputs.

### Negative feedback system

The usual method of obtaining a multi-channel response is by using an *LC* band-pass filter and gain control for each channel. The range of inductance needed to cover the ten octaves or so of the audio band makes the filters expensive and unattractive. In addition, much trimming is normally needed to obtain a basically flat response, due to crossover interactions between channels.

Negative feedback methods offer many advantages, such as reduced noise and distortion and accurate gain setting using potentiometers of linear law. In the case of the multichannel system, the filter specification may be greatly relaxed, and trimming can normally be eliminated.

A block diagram of this type of system is given in Fig. 1. At the centre frequency of a channel, and assuming no interaction between channels

$$|V_{out}|/|V_{in}| = R_a/R_b$$

If a simple tuned circuit bandpass filter is used, in order to cross over evenly between channels the $Q$ value should be $\sqrt{2^x}/(2^x-1)$, where $x$ is the channel spacing in octaves. In a negative feedback system this is not critical and the value of $Q$ can be raised to reduce the interaction, the penalty being a rise in noise at the crossover points. Error in the centre frequency of a filter has a similar effect; as a guide, approximately 1.5dB increase in noise is produced by 50% $Q$ error, or $15x$% error in centre frequency.

At a first glance it would seem desirable to make the first and last filters low and high pass respectively, but in actual fact this response is produced in a negative feedback loop using only bandpass filters. The penalty is increased noise again, but this time well outside the audio range, assuming a reasonable choice of channel frequencies has been made. Using only bandpass filters simplifies the system since only one basic filter type is required. The design of this network will now be considered.

**Performance** of the five-channel tone control

$-$3dB bandwidth at 1V r.m.s. signal level, controls flat: 8Hz-30kHz
distortion at 1V r.m.s. signal level, controls flat: 100Hz—0.05%
1kHz—0.05%
10kHz—0.05%
clipping level, controls flat: 2.9V r.m.s.

### Active bandpass filter

In some systems there could be thirty or more channels, and since there is one filter circuit per channel, this must be designed as economically as possible within the limits of the specification. Assuming no inductors are to be used for the reasons mentioned before, the number of active devices should be minimized, unless component tolerances can be relaxed by using more. Close tolerance capacitors can prove especially expensive.

A simple circuit that meets these requirements is the Wien bridge derivative[4] shown

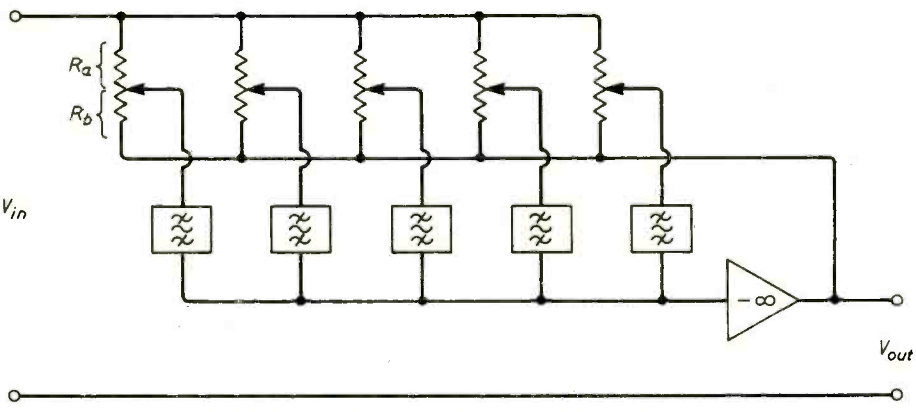



*Fig. 1. Simple block diagram of the multi-channel negative feedback system.*

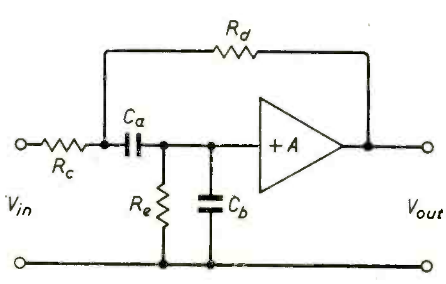



*Fig. 2. Example of a band-pass active filter.*

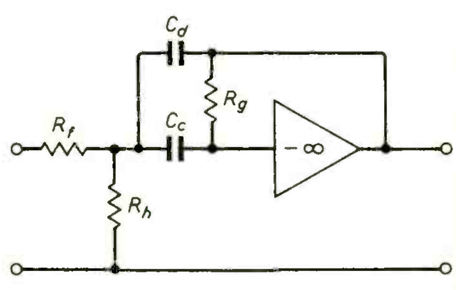



*Fig. 3. Band-pass filter using multiple feedback.*

*University of Durham

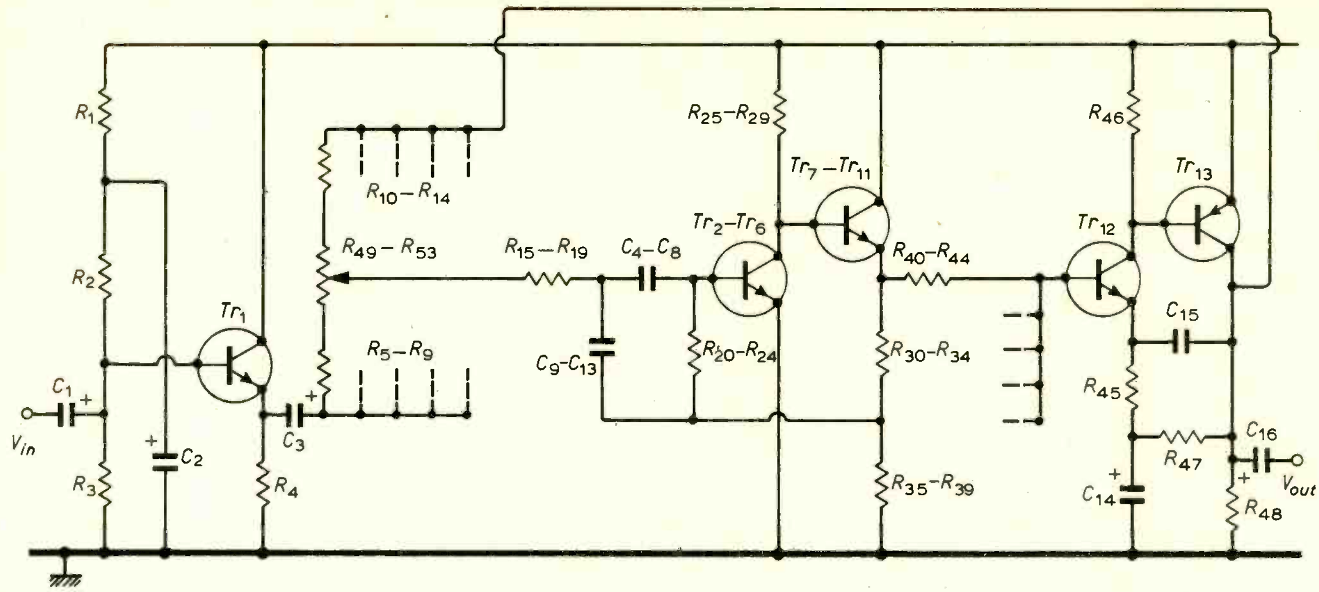



*Fig. 4. Circuit of the five-channel tone control unit. Only one of the filters and linear potentiometer is shown.*

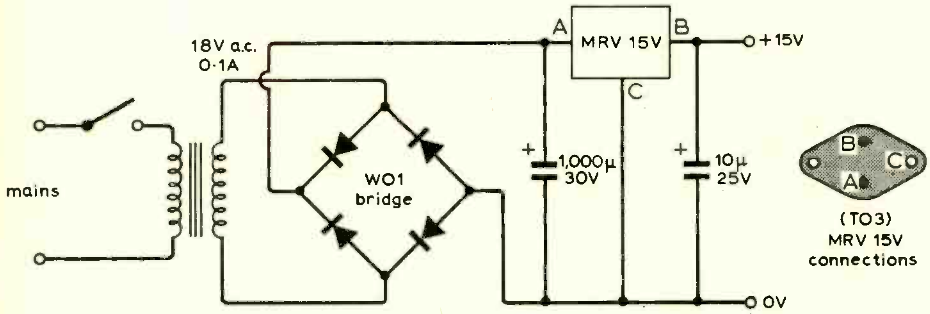



*Fig. 5. Suggested power supply circuit using an integrated regulator.*

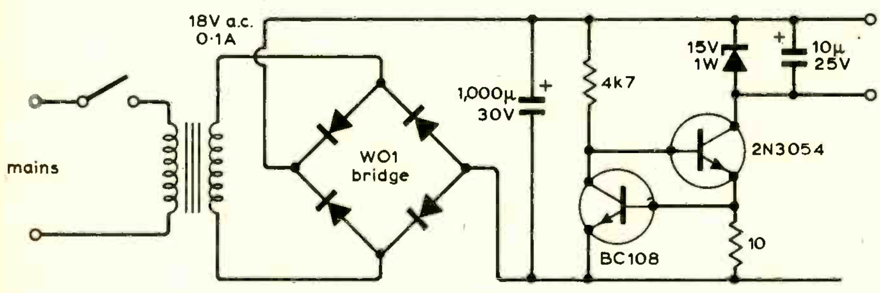
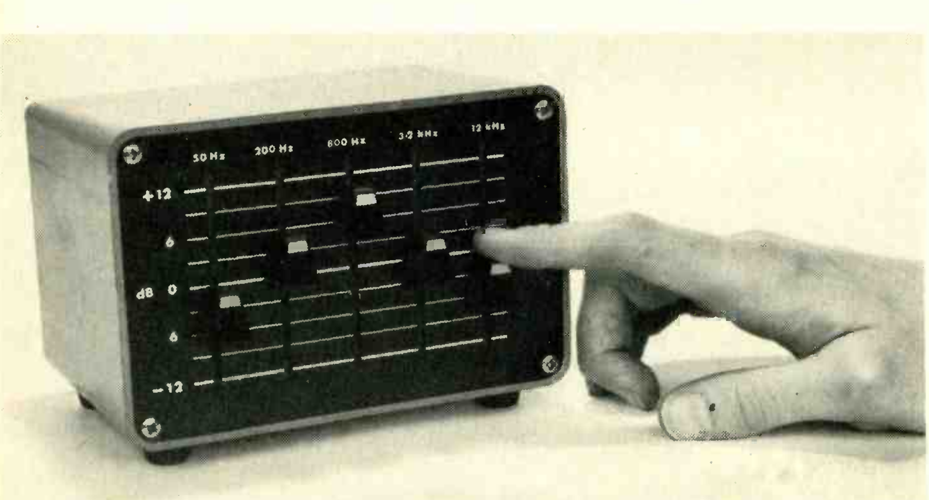



*Fig. 6. Alternative discrete component power supply.*




*Five slider potentiometer controls on the front panel can be set to represent the required amplitude frequency response.*

in Fig. 2. The response follows the tuned circuit law

$$V_{out}/V_{in} = -H\omega_0(j\omega)/\omega_0{}^2-\omega^2+a\omega_0(j\omega)$$

where $a = 1/Q$, $\omega_0$ is the resonant frequency and the gain of the voltage amplifier is

$$H = 1/3(6.5-a)$$

The component values are $C_b = C_a/2$, $R_c = 2/\omega_0 C_a$, $R_d = R_c/3$ and $R_e = 2R_c$. The most desirable feature of this circuit is that $R$ and $C$ values are independent of $Q$, and $\omega_0$ is independent of amplifier gain $H$. Unfortunately, the $Q$ value becomes extremely sensitive to the value of $H$ for $Q \geqslant 1$, and the margin of stability in such cases is narrow.

A circuit much more suited to this application[5] consists of an inverting op-amp with multiple feedback loops (Fig. 3).

The response of this circuit is the same as before, but the component values are $C_c = C_d$, $R_f = 1/H\omega_0 C_c$, $R_h = 1/(2Q-H)\omega_0 C_c$ and $R_g = 2Q/\omega_0 C_c$. If $H = 2Q$, $R_h$ can be left out and $V_{out}/V_{in}$ at resonance becomes

$$V_{out}/V_{in} = -2Q^2 = R_g/2R_f.$$

The minus sign in this expression indicates a phase reversal, so the main amplifier in Fig. 1 will now need an in-phase gain to obtain an overall negative feedback relationship.

The above equations for this active filter circuit show that $Q$, passband gain and resonant frequency are determined solely by two identical capacitors and two resistors. The demands on the op-amp are not great, and a single bipolar transistor suffices for low $Q$ values. The transistors are used in the circuits to follow to provide a high stage gain in addition to filtering. This reduces the noise contribution of the main amplifier, and so long as the gain is greater than the number of channels used, the dominant noise contribution is that due to the first transistor stage of the active filter. This means a signal to noise ratio of about 70dB,

Table 1

| Channel frequency (Hz) | $C_{4\text{-}13}$ ($\mu$F$\pm$10%) |
|---|---|
| 50 | 0.22 |
| 200 | 0.056 |
| 800 | 0.015 |
| 3.2k | 3,900p |
| 12.8k | 1,000p |

Table 2
Modified filter component values for narrower channel spacing. For worst case component tolerance, channel spacing error is 30%.

| Channel spacing (octaves) | $Q$ | $R_{15\text{-}19}$ (k$\Omega$) | $R_{20\text{-}24}$ (k$\Omega$) | $R_{30\text{-}34}$ (k$\Omega$) | Tolerance $C_{4\text{-}13}$, $R_{15\text{-}24}$ (%) |
|---|---|---|---|---|---|
| 1 | 1.7 | 3.9 | 47 | 6.8 | 10 |
| $\frac{1}{3}$ | 4.5 | 1.5 | 120 | 0.68 | 3 |

which is better than most preamplifier inputs.

### Practical circuit

The circuit is shown in Fig. 4. Only one filter is shown as the other four are identical, except for the values of $C_x$ which are given in Table 1. An emitter follower $Tr_1$ provides a low impedance input source for the bank of control potentiometers, $R_{49\text{-}53}$. The fixed resistors $R_{5\text{-}14}$ restrict the range of boost and cut to $\pm$12dB. The active filter consists of a common emitter amplifier with a d.c. coupled emitter follower output. The $Q$ value employed is unity and the passband gain at resonance should be approximately 28dB. The filter outputs are fed to the main amplifier through $R_{40\text{-}44}$ which also provide the d.c. bias for this stage. Overall h.f. stability is obtained from the 6dB/octave roll-off provided by $C_{15}$ and $R_{45}$.

The unit complete with power supply fits into a 16 × 11 × 11cm case without difficulty.

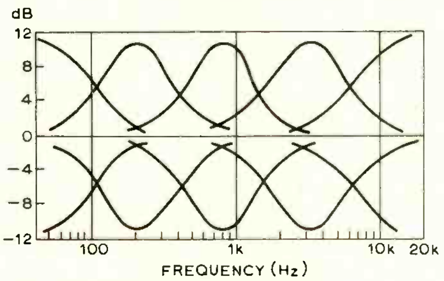



*Fig. 7. Typical response curves of the five-channel unit.*

*Slider pots mounted on the front panel are shown at the top with the main p.c. board (centre), which carries the filter circuitry and input/output devices. The power supply is on a separate board (bottom).*

A suitable power supply circuit using a monolithic regulator is given in Fig. 5. An alternative discrete component version, with a "ring of two" constant current generator feeding a zener diode in parallel with the load is given in Fig. 6. Either unit offers a ripple level which is inaudible with the unit in operation.

A small point worth noting is that calibration of the potentiometers in linear dB steps does not strictly follow the mathematical law, although only 10% error is produced over a 12dB range.

### More channels

The performance of the five channel unit is encouraging enough to consider expanding the controls in range and number. As for range of control, about $\pm$25dB is the most that would normally be required, even for special effects. One can obtain this range by reducing the values of $R_{5\text{-}14}$ down to 2.7k$\Omega$. To make sure that the overload margin is maintained under all conditions, it may be necessary to increase the standing current in $Tr_1$ and $Tr_{13}$ to provide sufficient drive voltage for the potentiometer bank. Transistors $Tr_1$ and $Tr_{13}$ may then have to be types of a higher dissipation rating. The number and spacing of controls will depend chiefly on application, thirty controls of one third octave spacing being a reasonable limit. The filter circuits can remain the same as the five channel unit; modified resistor values for two higher values of $Q$ are given in Table 2. Using these modified circuits does not significantly alter the capacitor values for a given frequency, which are given by the equation

$$C(\mu F) = 1(\omega_0\sqrt{R_f . R_g}) \simeq 11.8/f_0(\text{Hz})$$

### Components

Values for the power supply components are shown in Fig. 5 or Fig. 6.

**Transistors**

$Tr_{13}$ - BC212 All others BC109

**Capacitors**

| | |
|---|---|
| $C_1$ - 1$\mu$/10V | $C_{14}$ - 50$\mu$/10V |
| $C_2$ - 10$\mu$/15V | $C_{15}$ - 0.005$\mu$ |
| $C_3$ - 10$\mu$/15V | $C_{16}$ - 10$\mu$/15V |
| $C_{4\text{-}8}$, $C_{9\text{-}13}$ - $C_x$ (see table 1) | |

**Resistors**

| | |
|---|---|
| $R_1$ - 47k | $R_{30\text{-}34}$ - 10k |
| $R_2$ - 47k | $R_{35\text{-}39}$ - 680 |
| $R_3$ - 100k | $R_{40\text{-}44}$ - 22k |
| $R_4$ - 1k | $R_{45}$ - 100 |
| $R_{5\text{-}9}$, $R_{10\text{-}14}$ - 3.3k | $R_{46}$ - 10k |
| | $R_{47}$ - 4.7k |
| $R_{15\text{-}19}$ - 6.8k | $R_{48}$ - 1k |
| $R_{20\text{-}24}$ - 27k | *$R_{49\text{-}53}$ - 10k lin |
| $R_{25\text{-}29}$ - 100k | |

*Slider pots are "Alp" type LV60 (mono) or LG60 (stereo). The cheaper Radiohm types are also suitable.

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1. Baxandall, P. J., "Negative Feedback Tone Control", *Wireless World*, Oct. 1952.
2. Ambler, R., "Tone-balance Control", *Wireless World*, March 1970.
3. Hutchinson, P. B., "Tone Control Circuit", *Wireless World*, Nov. 1970.
4. Sallen and Key, *Transactions I.R.E.*, CT-2 No. 1, March 1970.
5. Huelsman, L. P., "Theory and Design of Active *RC* Circuits", McGraw-Hill, 1968.

# Conferences and Exhibitions

**1973 European Microwave Conference**
Sept. 4-7 Brussels
(Dr. G. Hoffman, Secretary General, ST Pietersnieuwstraat 41, B-9000 Ghent, Belgium)

**LASER 73**
Sept. 4-7 Munich
(Munchener Messe- und Ausstellungsgesellschaft, Theresienhohe 13, Munich, Germany)

**Royal Television Society Convention**
Sept. 6-9 Cambridge
(Royal Television Society, 166 Shaftesbury Avenue, London WC2H 8JH)

**Solid State Devices Conference**
Sept. 10-11 Nottingham
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

**First National Quantum Electronics Conference**
Sept. 10-13 Manchester
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX)

**Physics of Semimetals and Narrow-gap Semiconductors**
Sept. 12-14 Cardiff
(Dr. J. Aubrey, Dept. of Applied Physics, UWIST, King Edward VII Avenue, Cardiff CF1 3NU)

**First Indian Electronics Trade Fair**
Sept. 15-17 Bombay
(Taj Mahal Inter-Continental Hotel, Division of Trade Fairs and Exhibitions, Apollo Bunder, Bombay 1, India)

**Switching and Signalling in Telecommunications**
Sept. 16-22 Birmingham
(I.E.E. Savoy Place, London WC2R OBL)

**IEEE Electronics and Aerospace Systems Conference**
Sept. 17-19 Washington
(I.E.E.E., 345 East 47th Street, New York, N.Y. 10017, U.S.A.)

**Eleventh Modulator Symposium**
Sept. 18-19 New York
(I.E.E.E., 345 East 47th Street, New York, N.Y. 10017, U.S.A.)

**Electronic Prosthetics Conference**
Sept. 19-21 Lexington
(College of Engineering, University of Kentucky, Lexington, Kentucky 40506)

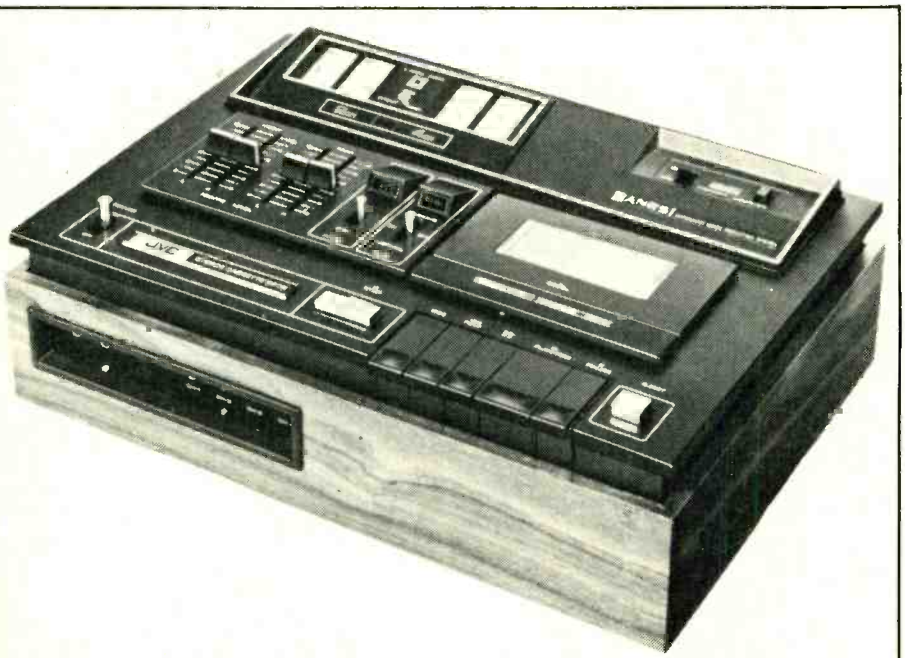
# Letter from America

There were a number of firms making projection TV in England around the 1950s — Decca, Valradio, Ferranti and White-Ibbotson come to mind — and I am sure there were many others. However, the idea never really caught on and production ceased after a few years. Servicing posed some problems, but the big disadvantage was the fact that the picture could only be viewed under cinema conditions. After all there was only 6 watts to play with and even with cathode and grid tube-modulation, plus the use of efficient aluminium screens, the picture was not that bright. Now, with the advent of better projection tubes — colour of course — large screen projection TV might well be "an idea whose time has come". Sony certainly think so and they have given some very impressive demonstrations recently. Henry Kloss of Advent also thinks so and his company will be marketing a system later this year. The early systems I mentioned all used a Schmidt optical system made by Philips. The aluminized mirror tended to collect dust and it was most difficult to clean without damaging the delicate surface. Henry Kloss also uses a Schmidt system but he has dealt with the problem very simply: *the whole thing is enclosed within the tube.* It does mean that the system has a fixed focus but the advantages of having the optical components free from dust and fingerprints more than compensates for this. Three tubes are used and the phosphors are deposited on $\frac{3}{16}$in aluminium subtrates. As the full colour picture is formed by the superimposition of the three images coming from different places there will obviously be some distortion. The varied angles of projection cause a kind of "pincushion" effect and because two of the tubes are angled slightly for convergence, the height of two of the images varies from left to right; in other words, a "keystone" distortion. These deviations are corrected by applying a complex compensating waveform to the scanning circuits.

The screen measures just over $5\frac{1}{2}$ feet by 4 feet and is spherical in shape with a 5-inch depth in the centre. It is made of aluminium foil bonded to a supporting material and the surface is indented by a pattern formed during a rolling process. This pattern gives the effect of a multitude of tiny lenses which define the viewing angles as well as improving the efficiency. Compared to matt white paper, the overall gain of the screen is said to be about 10. The loudspeaker is housed in the projection unit and the sound is reflected from the screen. Expected price is about $2500.

The Consumer Electronics Show was again held in Chicago's vast McCormick Exhibition hall and, predictably, quadraphonic sound was the main interest. Just as predictable — the majority of receivers had provision for both SQ matrix and CD-4 "discrete" records. One receiver from Onkyo had automatic switching. No details were available but I imagine the normal mode of operation is SQ and the presence of the CD-4 30kHz carrier operates the switching. A few receivers had SQ and CD-4 decoders built-in but the majority offered SQ with provision for an external CD-4 unit. Harman-Kardon pioneered the method of 2-4 channel bridge switching whereby each pair of output stages are effectively connected in series for 2-channel operation but now many more receivers (Marantz, Rotel, Sony, Pioneer) are employing this technique. How much do these receivers cost? Well, a typical a.m./f.m. quadraphonic receiver giving some 40 watts per channel would cost between $450 and $600. Half that power would bring down the price to about $299. The majority are fitted with some form of "joystick" balance control — some with visual indication using l.e.ds. The most conservative guess would put quadraphonics with 20% of the market but it is growing rapidly. Glenburn-McDonald have just announced a new turntable featuring a wide-range phono cartridge and built-in CD-4 discriminator to sell under $59. Very few CD-4 discs are available — only about 25 against 300 or more matrix types — but RCA promise a lot more by the end of the year.

JVC were showing their new quadraphonic cassette deck which has eight tracks on standard 0.15-inch tape. Two drive systems are employed; one for the reel and one for the capstan. With such a minute separation between tracks, crosstalk can be quite a problem but JVC claim that special phase shift and feedback circuits reduce crosstalk to a minimum. Actual figures quoted were 25dB (at 1kHz) — not as high as in conventional machines but acceptable enough for most purposes. Provision is made for $CrO_2$ tape and the JVC noise reduction system — ANRS — is built-in.




*First production cassette machine with eight-track, four-channel capability uses special circuitry to keep crosstalk to a minimum (−25dB at 1kHz). S/n ratio is quoted 48dB in the four-channel mode, presumably with JVC's noise reduction system.*

Eight-track tape is still immensely popular, especially for car use, and CBS recently introduced a 100-minute cartridge which can accommodate the double or triple "albums". Why a single record is called an "album" is inexplicable.

Sales of electronic calculators have been increasing by leaps and bounds and there were a number of new ones to be seen at the Show. One was the Commodore; a "super-mini" unit measuring only $4\frac{1}{2}$ inches by $2\frac{1}{2}$ by $\frac{3}{4}$ inches deep, priced at $39.95. It is a six-digit model with add, subtract, multiply and divide functions. TI had two new models, a 12-digit desk-top unit at $179.95 and another 12-digit unit with memory at $179.95. Casio were showing a new hand-held six-digit model costing $59.95 with an eight-digit model priced at $99.95. One sales manager said "before too long children are going to be carrying mini calculators to school like pencils".

According to Leibniz "It is unworthy of excellent men to lose hours like slaves in the labour of calculation" True enough, but I am still a little uneasy at the implications!

G. W. Tillett.

# Simple Facsimile or Teleprinter Signal Converter

*by J. B. Tuke*

**The author describes here a simple and reliable signal converter unit suitable for driving both facsimile and teleprinter machines from the a.f. output of a communications receiver. Phase-lock-loop technique is used which has the ability to detect extremely weak frequency-shift keyed radio transmissions, under conditions of low signal/noise ratio, and eliminates the use of bulky and parameter restricting LC filter circuits which would be normally used.**

To interface a communications receiver with either facsimile recording or teleprinter machines, a signal converter is required. Fundamentally the method of transmission for both systems are of the same type utilizing two level f.s.k. Different information rates and frequency shifts may be used depending on the transmission frequency and mode used.

Satellite transit predictions are broadcast via radio teleprinter and these being of immense value to stations equipped for the reception of weather satellite facsimile transmissions, the need for a converter or "terminal unit" which will deal with both forms of signals is evident.

### Reception of f.s.k. signals

The facsimile transmission of a weather picture takes the form of a frequency shift keyed signal in which the r.f. carrier is on one of two frequencies according to whether a black or white part of the picture is being transmitted at that instant. It should be noted that with this type of signal there are no intermediate shades of grey — the signal is either black or white. Since almost all facsimile recording machines in use are amplitude operated devices, where no signal means black and maximum signal means white, the job of the converter will be to change the frequency variations of the transmitted signal into amplitude variations suitable for feeding into the picture recorder.

A teleprinter is, in almost all cases, operated by feeding reversing currents into the operating coil. The transmission is still f.s.k. — the two frequencies correspond to the "mark" and "space" characters of the Murray five unit code. In this case the converter or terminal unit must change the r.f. signal into output current "reversals". It does not require much imagination to see that if the facsimile converter can produce amplitude changes corresponding to frequency changes, it will require only a simple relay to further change these amplitude variations into reversing d.c.

The NE560B integrated circuit, provides the basis for a simple terminal unit which can deal with both facsimile and radio teleprinter signals. This will permit both data systems to be decoded and driven from a conventional communications receiver. This Signetics i.c. is a "phase-locked-loop" device in which a local oscillator, in fact a voltage controlled oscillator or v.c.o., locks onto an incoming signal by means of an error voltage which is produced by a phase comparator. An example of operation using typical frequencies follows.

Suppose the v.c.o. is free-running at 1500Hz. If an input signal above this frequency, say 1600Hz, is applied to the equipment, the v.c.o. is locked to this frequency by the error voltage generated by the phase comparator. The v.c.o. therefore has the same frequency as the incoming signal but there will, of course, be a constant phase error between the two which is proportional to the v.c.o. control voltage. If the input frequency is now changed to some figure below the free-running frequency, say 1400Hz, the v.c.o. would shift to that figure generating, in the phase comparator, an error voltage of the reverse sign. In the i.c., the error voltage does not, in fact, reverse sign but changes the level around a mean d.c. or quiescent value. The relationship is illustrated diagramatically in Fig. 1.

If the error signal derived from the comparator is fed (after suitable buffering) to a Schmitt trigger, it may be arranged so that one signal frequency produces a voltage which switches the trigger on, while the other switches it off. If an amplitude modulated signal is required to operate the facsimile recorder, the Schmitt trigger may be made to key a tone oscillator. For teleprinter use, the trigger may be used to operate a suitable high speed relay, via a transistor driver, which can provide the current reversals required.

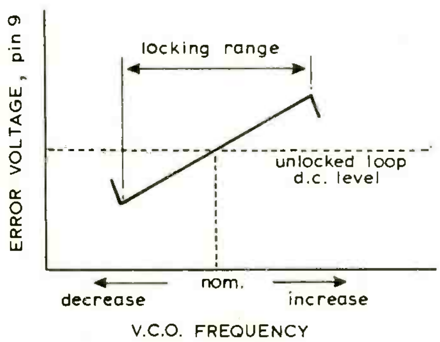



*Fig. 1. Response of phase-lock-loop over locking range.*

### Practical considerations

In designing a practical unit using the scheme described above, the first item to consider is the frequency at which the i.c. is to function. It could be at the receiver i.f. but few equipments have accessible i.f. outputs. It is preferable therefore to operate in the a.f. range, making the unit compatible with any receiver having a b.f.o.

Any frequency shift transmission, when received with the b.f.o. switched on, results in two audio tones. The pitch of the tones produced will depend on the b.f.o. setting but if the signal is tuned sufficiently to one side of the i.f. centre frequency, the tones will always differ in frequency from each other by the degree of shift employed at the transmitter. On the h.f. bands, this is typically 800Hz while on the l.f. bands — below 150Hz — it is 300Hz. The NE560B is capable of following frequency shifts up to 30% of the operating frequency. If the shift is 800Hz, the lowest operating frequency is therefore around 2700Hz. It is inadvisable to design to maximum limits so that if the i.c. capability is reduced to 25%, the mean frequency will be 3200Hz. A shift of $\pm$ 400Hz then represents a total of 25% and is comfortably within the working limits of the i.c. The tones to be fed to the i.c. are therefore 3600 and 2800Hz. These frequencies may be attenuated, to some extent, by top cut capacitors fitted in the receiver to reduce noise, so some component removal may be necessary in the receiver a.f. stages. It may also be necessary to adjust the b.f.o. coarse tuning control to ensure that a sufficiently high beat note is available.

The performance of the NE560B is governed very largely by the amplitude value of the input signal. The range over which the oscillator will lock, expressed as a percentage of the centre frequency, is dependent, amongst other things, upon this parameter. It is very important consequently that the signal be properly conditioned before being fed to the i.c. This conditioning implies amplification and limiting and a convenient method of doing this here is to employ a CA3076 i.c. as a pre-amplifier. Although designed for r.f. use, there is no reason why this circuit cannot be used at lower frequencies provided the by-pass capacitors are increased accordingly. The 3076 will limit adequately with an input exceeding some $50\mu V$, and the amplitude of the output is determined by the value of the output resistor. A suitable figure is $51\Omega$, which provides 20mV of signal to drive the NE560B. The full circuit is shown in Fig.2.

The error voltage output from the phase-lock-loop, $IC_2$, is available in amplified form at pin 9. The recommended load to ground is in the order of $15k\ \Omega$ and the use of a transistor as part of that load, as suggested in an application note from Signetics, changes the load impedance with signal, thereby providing some small amplification. The available voltage change, for $\pm 10\%$ change of frequency, is in the order of $\pm 1V$ which is then used to operate the trigger circuit $Tr_2$ and $Tr_3$.

It is desirable that the trigger should operate with the minimum change of voltage, and the circuit shown will switch for a change of about 0.3V which means that if the Signetics i.c. will deliver a voltage of $\pm 0.15V$, the trigger will operate satisfactorily. Since about $\pm 1V$ is expected, there is plenty of voltage change in hand and trigger operation will be absolutely clear-cut.

The degree of filtering prior to the trigger is quite critical and if $C_{12}$ is too low a value, the trigger will operate from the break-through of input signal superimposed on the changing d.c. at pin 9, and if too high, very brief signals, such as exist in facsimile transmission, may not operate the trigger at all. The value shown is a compromise but if the unit is to be operated solely for teleprinter work, this may safely be doubled or even trebled.

## Machine interfacing

For working into a facsimile machine, the trigger is used to operate a gate which keys a local oscillator. This is conveniently arranged as shown using an f.e.t., $Tr_5$, as a keyed amplifier. The trigger output is either +4 or +14V with the values shown and with the source of the f.e.t. held at + 9V by zener diode $D_3$, it is either on or off according to the state of the trigger.

The local oscillator may be any convenient design, say a small phase-shift oscillator and buffer, running at about 2500Hz. The waveform must be reasonably pure as otherwise the facsimile amplifier-rectifier may not operate correctly.

When radio teleprinter reception is required, the simple driver circuit shown will operate a "type 7" receive teleprinter. The +4/+14V available from the Schmitt trigger is passed via a 6V zener diode $D_2$ and asuitable current limiting resistor $R^{20}$ at the base of driver transistor $Tr_4$. At this point the signal appears as 0V or +6V and the transistor switches fully on or off. The resulting collector current operates a Siemens high speed relay, with the two $1000\ \Omega$ coils connected in parallel instead of the more usual series arrangement. The relay contacts should be adjusted for a 0.002in gap and the setting of the spring tension is discussed in setting up below.

There are only 3 controls on the converter; tuning, lock-range and trigger. These only need adjustment when changing to different shift values. The tuning control $R_8$ determines the centre frequency to be used and the performance of the unit is degraded when the potentiometer is more than $\frac{2}{3}$ of the way towards the h.f. end. Useful limits with the values shown are from 1000 to 4000Hz which is an adequate range for normal use. If very narrow shift is to be used, $C_{10}$ should be increased to lower the mean operating frequency to the desired figure.

The lock-range control $R_7$ can only reduce the bandwidth over which the i.c. can follow to below the 30% maximum figures quoted. In most cases it is left fully "open", i.e. maximum lock-range, but under conditons of small shift and interference it may be reduced to advantage. unfortunately, this control also alters the centre frequency, to some extent, so adjustment under working conditions may become difficult.

The third control $R_{12}$ adjusts the off-set voltage of the trigger to match the steady voltage of the i.c. output.

## Setting up

It is strongly advised that the unit be set up to the desired standards before being put into service. The controls are all, to some extent, interdependent and adjusting under working conditions is likely to have as much success as fiddling with the i.f. cores of a TV while watching the picture!

Initial setting up requires only an a.f. signal generator and a pair of high impedance headphones. A basic oscilloscope is handy for correct adjustment of the

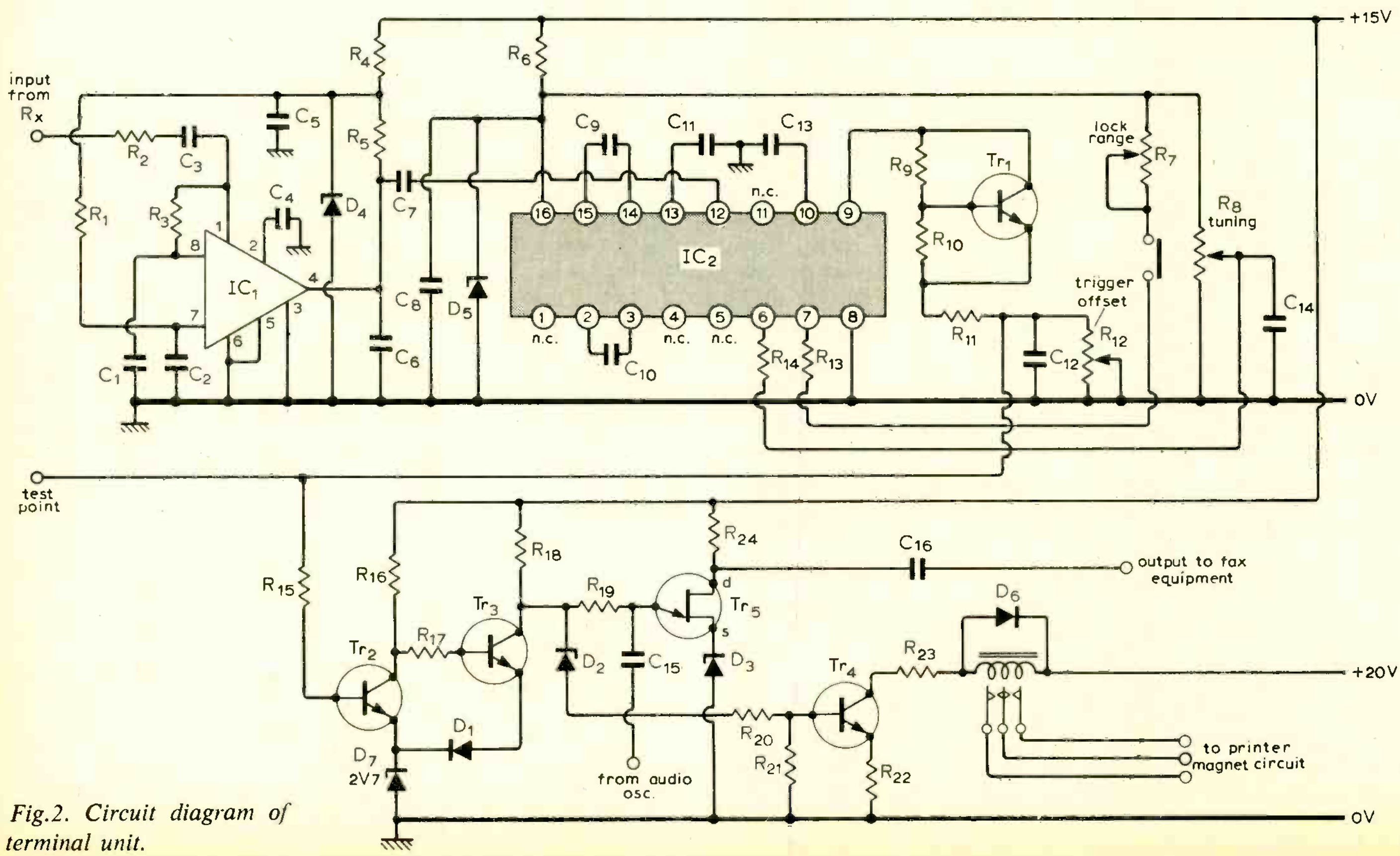


*Fig.2. Circuit diagram of terminal unit.*

receiver b.f.o. and to indicate that the converter is "on the correct frequency".

Having determined the shift to be employed, proceed as follows: let us assume a shift of 800Hz. The mean operating frequency will be, say, 3200Hz. Connect the headphones between "test point" and earth and feed a 3200Hz signal from the signal generator to the converter input. Adjust the tuning control until a pure tone is heard from the phones. Adjust the signal generator, decreasing the frequency, until a rasping, low frequency beat note is heard. This is the l.f. limit of the phase-lock-loop and the frequency should be noted (e.g. 2900Hz). Now, increase the generator frequency until the rasping note is again heard (e.g. 3600Hz). A quick calculation will show that the centre frequency of the loop is 3600 + 2900 or 3250Hz. Adjust the

2

tuning control to slightly lower the frequency and repeat the checks, as necessary, until the lock-range is symmetrical about the desired centre frequency.

If the lock-range is excessively wide for the shift to be used, the lock-range control should be advanced slightly and the tuning re-adjusted until the required range is achieved. Normally the lock-range should exceed the shift by about 5%, otherwise the slightest frequency drift in the phase-lock-loop or the receiver will cause faulty operation. Therefore, using the generator, set the required locking width. Set the signal generator back to the correct centre frequency and transfer the phones to the facsimile output terminal. Adjust the trigger offset control $R_{12}$ to a point midway between trigger on and off. The trigger may "jitter" at this setting as it tries to follow the breakthrough of the 3200Hz. Now, increase the generator frequency to a point where the trigger is firmly on. Note this frequency. Similarly, reduce the signal frequency until the trigger is shut off. Again note this frequency. These frequencies will be typically ±50Hz around the centre frequency and adjustment should be made for symmetry about this point.

An oscilloscope may now be connected to the "test point" and some f.s.k. signals can now be fed into the input from a receiver. When the correct tuning point is obtained, a pattern similar to that shown in Fig.3. will result, together with correct trigger operation. Detuning the receiver will result in large "spikes" appearing on the picture (Fig.4) together with random operation of the trigger.

Once the signal is correctly tuned in, the trigger offset control may be shifted in either direction to produce optimum results. If the two incoming tones are absolutely correct, the adjustments made during the setting up procedure will be satisfactory. However, this state of perfection may not always exist and if the signals are off frequency (but inside the lock-range) then a slight adjustment to the offset control will ensure proper trigger operation. This control is not all that critical and may be adjusted under working conditions without difficulty.

There only remains the adjustment of the

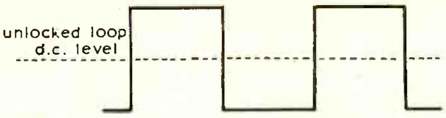



*Fig.3. Correct tuning for f.s.k. signal.*

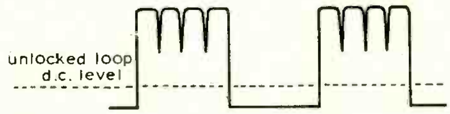



*Fig.4. Incorrect tuning where one frequency is outside the locking range.*

high speed relay for use with a printer. If $IC_2$ is temporarily removed from its socket, a positive-going square wave may be applied to the trigger via the "test point". This may conveniently be obtained via a small diode and resistor (acting as a polarity sensitive switch) from the a.f. signal generator.

A frequency of 25Hz should be used (corresponding to a maximum rate of 50 bauds) and the output from the high speed relay contact examined on an oscilloscope. If a double beam oscilloscope is used correctly in the chopped mode, the relay spring should be adjusted until the output waveform from the relay matches, as closely as possible, the input waveform from the signal generator. Once set, this should require no further adjustment.

The complete unit requires 15V d.c. (negative earth) and draws about 30mA. Supply stabilization is provided by zener diodes $D_4$ for $IC_1$ and $D_5$ for $IC_2$.

Components may be mounted in any convenient fashion, p.c.b., Veroboard or on a plain sheet of copper laminate, as wiring is relatively non-critical.

### Transmission information

Radio teleprinter and facsimile transmission data can be obtained from the World Met. Organization, Geneva or, for British transmissions, in publication 510 a, b & c, from H.M.S.O. One problem with h.f. facsimile is multipath transmission, giving rise to ghosting on pictures, so that choosing the optimum frequency becomes important. This effect is less noticeable on radio teleprinter signals due to the longer time constants and l.f. facsimile transmissions seldom suffer from this condition.

### Components list

| | | | |
|---|---|---|---|
| $R_1$ | 100Ω | $R_{13}$ | 22kΩ |
| $R_2$ | 22kΩ | $R_{14}$ | 3.3kΩ |
| $R_3$ | 5.6kΩ | $R_{15}$ | 3.3kΩ |
| $R_4$ | 250Ω | $R_{16}$ | 6.8kΩ |
| $R_5$ | 51Ω | $R_{17}$ | 15kΩ |
| $R_6$ | 100Ω | $R_{18}$ | 5.6kΩ |
| $R_7$ | 100kΩ pot | $R_{19}$ | 100kΩ |
| $R_8$ | 20kΩ pot | $R_{20}$ | 22kΩ |
| $R_9$ | 8.2kΩ | $R_{21}$ | 47kΩ |
| $R_{10}$ | 3.3kΩ | $R_{22}$ | 33Ω |
| $R_{11}$ | 2.2kΩ | $R_{23}$ | 33Ω |
| $R_{12}$ | 5kΩ pot | $R_{24}$ | 5.6kΩ |

| | | | |
|---|---|---|---|
| $C_1$ | 6.4μF | $C_9$ | 0.005μF |
| $C_2$ | 50μF | $C_{10}$ | 0.08μF |
| $C_3$ | 0.1μF | $C_{11}$ | 6.4μF |
| $C_4$ | 6.4μF | $C_{12}$ | 0.004μF |
| $C_5$ | 200μF | $C_{13}$ | 0.04μF |
| $C_6$ | 0.1μF | $C_{14}$ | 0.1μF |
| $C_7$ | 0.47μF | $C_{15}$ | 0.01μF |
| $C_8$ | 200μF | $C_{16}$ | 0.01μF |

| | |
|---|---|
| $IC_1$ | RCA CA3076 |
| $IC_2$ | Signetics NE560B |
| $Tr_1$ | BC108 |
| $Tr_2$ | BC108 |
| $Tr_3$ | BC108 |
| $Tr_4$ | 2N2538 |
| $Tr_5$ | 2N3819 |
| $D_1$ | 1N914 |
| $D_2$ | BZY88 – C6V2 (6.2V zener) |
| $D_3$ | BZY88 – C9V1 (9.1V zener) |
| $D_4$ | BZY88 — C9V1 (9.1V zener) |
| $D_5$ | BZY88 – C12 (12V zener) |
| $D_6$ | 0A91, AA215 or similar |
| $D_7$ | 2.7V zener diode |

# Sixty Years Ago

The "Questions and Answers" section of the 1913 *Wireless World* makes as fascinating reading today as it must have done sixty years ago. The attitude adopted by the resident oracle is somehow reminiscent of the no-nonsense approach of some of the more matriarchal women's magazines. This impression is enhanced by the omission of the readers' queries, causing one to speculate on the possibility that they were rather too intimate for public exhibition. For example, a reply to "W.P." of Lanark . . . "W.P. shows from his question that he had better study the instructional articles now appearing in THE WIRELESS WORLD before attempting experimental wireless". W.P. (Lanark) must have felt like throwing the whole thing up and cultivating prize haggis instead.

The same advice was peremptorily handed to J.F.W., who was told: "Size of helix, etc., has little to do with distance of transmission; height of aerial (which you do not even mention) has a great deal. Evidently you need to read the series of instructional articles very carefully before commencing work". . . Ah, well, back to the drawing board.

The oracular dispensation to J.W.T. was, perhaps, the most intriguing in that month's answers: "(1) Your diagram, though neat enough, is the most mysterious of all those we have received. No indication is given as to where the three terminals shown are connected with the tuning inductance or its sliders; no parts of the apparatus are labelled, and some of it is quite beyond our powers of guessing. Study the diagrams appearing in many places in THE WIRELESS WORLD, and learn how to represent what you want to represent. . . . . ."

Fighting words — people evidently needed thick skins as well as ingenuity to listen to what the wild waves were saying.

# New Products

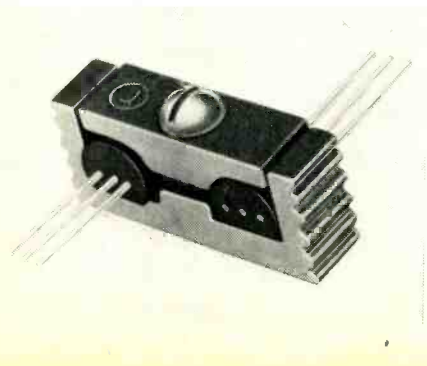
## 15MHz dual trace oscilloscope

The Meteronic Type 201 dual trace 15MHz oscilloscope offers a wide range of features in a portable instrument form. Plug-in time base and amplifier modules allow the user to select the configuration best suited to his needs and an internal voltage and time calibration signal is provided.

Sensitivity is 5mV/div at full bandwidth and the fastest sweep speed is 100ns/div. The t.t.l. trigger circuits operate to 20MHz and triggering may be from either channel or external. The display mode may be either A, B, A and B chopped or A and B alternate. A battery option is soon to be available. The instrument weighs 3.5kg and measures 111 × 260 × 222mm. The U.K. list price is £170. Meteronic Ltd, 114/116 Shipbourne Road, Tonbridge, Kent.
**WW317 for further details**

## Temperature balance heat sinks

The Redpoint type 92DC heat sink available from Celdis is designed to take two TO92 case plastic transistors and is thus ideal for applications such as complementary pair amplifiers, strain gauge amplifiers, or any other circuit where two devices are to work in a balanced condition, a situation which is assisted when the case temperatures of the two devices change in the same way. The size of 92DC dual heat sink is $\frac{3}{4} \times \frac{3}{16} \times \frac{5}{16}$ in, with a green anodized finish, and a thermal rating of 80°C/W. Price is 7.9p each for quantities greater than 100. Similar dual



heat sinks for temperature balancing are the type 5DC/HA, providing a thermal rating of 50°C/W for use with TO5 transistors, and the 18DC/HA with the same thermal rating, but for use on TO18 transistors. Prices for these are 21.3p and 20p each respectively (for quantities again in excess of 100). Celdis Ltd, 37/39 Loverock Road, Reading, Berks, RG3 1ED.
**WW311 for further details**

## Plastic connector for audio

A new connector has been introduced by Sealectro Ltd for use in audio equipment. Designed initially to meet stringent European safety regulations, the new connector, part number 300A003, has an all plastic body, three pins and a slide engagement. It is suitable for operation at up to 125 volts, 4 amps, and the socket contacts are recessed for complete safety.

The chassis socket is flange mounted and the free plug has an unusual cable grip providing a firm anchorage. Cables from 5.8-6.5mm diameter may be used. The mated length is 63mm and diameter 18mm. Sealectro Ltd, Walton Road, Farlington, Portsmouth, Hants PO6 1TB.
**WW306 for further details**

## Belt driven turntable

Two new automatic record turntables have recently been introduced by Garrard. The Zero 100 SB is similar to the earlier Zero 100 (which has a pivoted head for tangential tracking), but is now a belt driven unit providing drive to a heavy

zinc die-cast platter. Also included is a record counter for monitoring stylus wear.

The 86 SB is a belt driven development of the earlier AP76 and is similar to the Zero 100 in most features except that a conventional pick-up arm is used. Main specifications common to both models are: motor — screened four-pole synchronous; drive — belt from two-step motor pulley; wow and flutter — typically 0.12 peak; rumble — 63dB; bias compensator on both models is calibrated for both conical and elliptical styli; stylus force — 0 to 3gm, minimum recommended $\frac{3}{4}$gm. Garrard Engineering Ltd, Swindon, Wilts.
**WW302 for further details**
(Zero 100 SB. Price £54.83 + v.a.t.)
**WW304 for further details**
(86 SB. Price £40.31 + v.a.t.)

## Magnetic probe

Available from Interskill Ltd, this magnetic probe (The Magniprobe) replaces the conventional test magnet. It is no larger than a fountain pen and has a clip for carrying in the pocket. Originally developed for the easy identification of nickel aluminium conductors in miniature thermocouples, it incorporates a pivoting needle which is claimed to be many times more sensitive to low magnetic energy than is any hand held magnet.

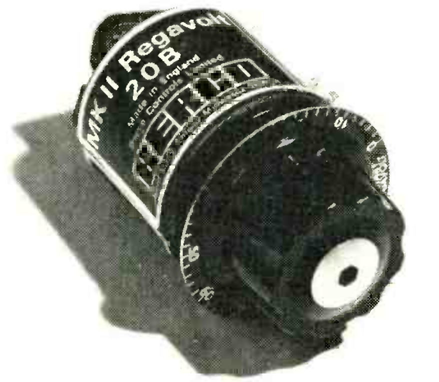
The applications of this instrument are said to be innumerable and include the checking, at all stages, of conductor polarity in complex thermocouple installations; checking changes of magnetic state in some alloys due to heat treatment conditioning; checking the quality of screws and other inserts assembled in positions inaccessible to the conventional magnet; establishing the polarity of small unmarked magnets used with reed relays and similar devices and for extracting fine magnetic swarf from small holes.

List price is from £4-£5 according to the quantity required and single Magniprobes for trial purposes are available at £5.50 including v.a.t. and carriage paid from Interskill Ltd, 121 Cambridge Road, Milton, Cambridge CB4 4AT.

**WW314 for further details**

## Variable transformers

Designated the 20 and 30 series, the Mk II Regavolt units from Berco have several interesting features. A new design of rotor brush arm provides metal to metal clamping using non-corrosive resistant steels, the contact arm being manufactured in beryllium copper which is heat treated to ensure stabilized brush pressure throughout its working life. Very low torque is required for rotation 3.5N cm (5oz.in) and these units can also be supplied in "ganged" form.




The 20 series Regavolt is primarily designed for the aircraft industry and provides a stepless control of power from 0-120W on 120V, 400Hz supplies. The 30 series has many applications such as simple motor speed control for d.c. motors, heating and ventilation control systems and light dimming applications. Berco Controls Ltd, Baird Road, Enfield, Middx. EN1 1UA.

**WW 307 for further details**

## Video-level meter


A new video-signal level meter was shown for the first time by Philips at this year's International Television Exhibition in Montreux and is available from Pye Unicam Ltd. Designed to perform signal-level measurements on composite TV signals, the PM 5548 is claimed to be the first instrument of its type available anywhere in the world.

A feature of this instrument is that it can accurately measure an instantaneous signal level at any point in a composite video-test signal to the very high accuracy of 0.1% $\pm$ 1 digit. This measurement is displayed digitally on a four-digit display, the measurement range covers − 600mV to + 1400mV relative to the blanking level. Additionally, a b.c.d. output of the measured value is optionally provided for driving a printer or other remote device, and a d.c. output for recording purposes.

Complete operation of the PM 5548 is based upon use of sampling techniques, a sample being taken from the video-test signal and used as a means of gauging the appropriate signal-component level. Via front-panel controls, the width of this pulse, the line on which it is employed, and its position on that line can be controlled. It is also possible for this sampling pulse to be applied over a number of adjacent lines (up to 50) and for the pulse width to be varied from 0.3 to 10$\mu$s. Measurements can be made on any section of the TV signal (both monochrome and colour) including the blanking period and sync pulse.

A further feature of this instrument is that the sampling pulse can also be employed as a marker pulse. In this mode it shows, via a monitor or oscilloscope, exactly which area of the video-test signal is being sampled. This marker, which can be applied positively or negatively, is also available as a separate output for Z-modulation of, for example, an oscilloscope.

Apart from its use independently in TV studios, etc, the PM 5548 can also be employed in conjunction with Philips PM 5546 video calibration generator. This unit provides the high-accuracy signals needed to check and align monitors, encoders, decoders, mixers, and other video equipment. Pye Unicam Ltd, Cambridge CB1 2PX.

**WW318 for further details.**

## TV sound channel pick-up

Since few TV sets are fitted with an audio output to connect to hi-fi amplifiers, Multitech Corp. have designed a device which will pick up the radiated i.f. from the TV set and demodulate it to provide a suitable audio feed for an amplifier. The probe is designed to be placed (using an adhesive Velcro pad) on the back or side of the television set at a point producing optimum signal-to-noise and the unit, battery powered or with a small mains adaptor fitted, will stand on the set-top. Several adaptations are possible as the basic unit contains a synthetic stereo decoder which can be exchanged for a true stereo decoder (Zenith pilot tone) or an amplifier which will drive an inductive loop for hearing aids. Performance specification is as follows: a.m. rejection 50dB; 3dB gain bandwidth 200kHz; distortion, 0.5% at 1kHz for 25kHz deviation; frequency response, 20Hz to 20kHz $\pm$0.5dB, output 250mV r.m.s. at 5k$\Omega$ Multitech Corp, Nybovej 1 — 2500 Valby, Denmark.

**WW 320 for further details**

## Direct reading 30kV meter

Believed to be the only one of its kind available in the U.K., a 30kV meter from Brandenburg Ltd, provides a compact and portable instrument with high accuracy. Operated by 9V internal batteries linked to a built-in checking facility, the meter is flashover and transient proof and measures only 178 × 114 × 127mm (7 × 4.5 × 5in). Accuracy is 1.0% f.s.d. over the meter's range of 0-30kV d.c. and the high input impedance of 30,000M$\Omega$ means that the current drawn under test of less than 1$\mu$A is unimportant.

Positive or negative ground is selected by a switch mounted on the front panel which also houses the clear 4.5in scale meter. Battery life is 800 hrs. Brandenburg Ltd, 939, London Road, Thornton Heath, Surrey.

**WW 308 for further details**

## Digital tracking voltmeter

The VID Tracking Voltmeter from Gay of Milan and marketed by Lyons Instruments, is an instrument which, in addition to operation as a normal d.c. digital voltmeter, has a peak reading memory voltmeter capability with the ability to read "maximum" or "minimum".

A new "continuous conversion" principle is used in which the tracking voltmeter continuously follows the input signal, providing a steady state indication when the input is constant, and continuous updating when the input changes. When the input changes only the variation is digitised to cause an increase or decrease in the displayed value (and b.c.d. output) and hence this "tracks" the input signal.

As a conventional d.v.m., the tracking voltmeter provides accuracy of ±0.05% of reading, ±0.02% of range with automatic polarity indication on four ranges of ±0.9999V, ±9.999V, ±99.99V and ±999.9V. The floating input provides an impedance of 10,000MΩ on the 1V range and 1.1MΩ on the other three.

The above specifications apply both for the normal mode and for the "maximum" and "minimum" peak holding memory modes. In the "maximum" mode the polarity switch can select either positive or negative peaks, whilst in the "auto" polarity position the absolute peak value (greater of positive or negative) is displayed, the polarity indicator acting as a polarity memory.

The unique "minimum" mode features the capability to measure and store the minimum instantaneous value (see picture) of a varying d.c. voltage, for example a fast voltage drop.


The Gay Milano VID tracking voltmeter is only 180 × 50mm panel size by 220mm deep. Weighing 1.8kg, it requires only 15VA mains power. Price is £250 duty free, £275 duty paid, including b.c.d. output and logic level remote control inputs. Lyons Instruments Ltd, Hoddesdon, Herts.

**WW315 for further details**

## True r.m.s. analogue voltmeter

Datron Electronics have announced a true r.m.s. analogue voltmeter designated Type 1115 which utilises what is claimed to be an entirely new type of true root mean square sensing circuit for the measurement of both sinusoidal and non-sinusoidal waveforms. The circuitry used in the 1115 is reported to overcome the shortcomings of thermal r.m.s. to d.c. converters by directly computing the true r.m.s. value of an input signal. The instrument comprises a precision wideband preamplifier with a selectable low pass filter, an r.m.s. computation circuit and a 3 pole integration filter having two selectable time constants. The instrument has a bandwidth of d.c. or 1Hz to 1MHz; 12 voltage ranges from 3mV to 1kV and an accuracy of 1% full scale below 100kHz. Crest factor is 10:1 (full scale) and the instrument will withstand a 1kV overload on all ranges.

Price £260. Datron Electronics Ltd, Hotblack Road, Norwich, Norfolk.

**WW313 for further details**


## Mini-power supplies

Recently introduced by ITT Components Group Europe is the Powercard "Size Two" — the first major extension of the range of p.c.b.-compatible power supplies launched last year. The new Powercard is larger (16 × 10 × 5.5cm) and provides 15W against 7½ from the standard Powercards. This is sufficient to supply a full 19in rack shelf of i.cs in most applications. Foldback overcurrent protection is standard and the input voltage ratings are 99 to 132V or 198 to 264V a.c. at 48 to 65Hz. The six Powercard "Size Two" specification codes are:

| | | |
|---|---|---|
| PC500C | 15/15 | : 0.5A at ±12 to ±15V tracking o/ps. |
| PC500D | 15/15 | : two isolated 0.5A o/ps at 12 to 15V. |
| PC500E | 5/15 | : two isolated 0.5A o/ps at 5 to 6V and 12 to 15V. |
| PC1000A | 15 | : 1A o/p at 12 to 15V. |
| PC500F | 30 | : 0.5A o/p at 24 to 30V. |
| PC3000A | 5 | : 3A at 5V ranging to 2.5A at 6V. |

ITT Components Group Europe, Rectifier Division, Edinburgh Way, Harlow, Essex.

**WW301 for further details**

## Large-screen video monitor

The Electrohome range of video monitors marketed by Bell & Howell A-V now includes a new 23in model, the EVM-23 V5. Designed for applications where picture size is as important as quality, it is suitable for message displays at hospitals and airports, computer read-out terminals and educational television in classrooms and lecture theatres. A solid-state monochrome monitor, the EVM-23 V5 is built to professional standards and includes among its features, high video input impedance, external sync input and plug-in transistors for ease of service.

Provision is made for asynchronous operation and there is remote control for brightness and contrast adjustment.

Resolution is claimed to be greater than 1,000 lines in the central 80% of the display area, and picture brightness is 513.9cd/m$^2$ under 80% white field conditions. All primary and most secondary controls are on the front of the monitor and are protected by a lockable panel. Price, £141. Bell & Howell A-V Ltd, Alperton House, Bridgewater Road, Wembley, Middx HAO 1EG.
**WW316 for further details**

## High speed water fuse

Industrial Instruments Ltd, announce the introduction of a water filled fuse holder suitable for experimental situations. There are many applications in power electronics where expensive, pure silver fuses are blown deliberately during testing. Some of these may cost several pounds each. The Transifuse is a way of reducing these costs to that of a piece of copper wire.

The water filled fuse has a sufficiently fast rupture period, provided suitable diameter wire is used, to ensure the

protection of the most expensive power semiconductors. Current rating is from 25 to 100A with up to 200A permitted intermittently. Voltages up to 415V a.c. or d.c., depending upon current capability are permissible. Price, one off £3.35 with reductions for larger quantities. Industrial Instruments Ltd, Stanley Road, Bromley, Kent, BR2 9JF.
**WW 310 for further details**

## Film capacitors

The new ITW-Paktron Micromatic polypropylene (PP) and polyester (PT) film capacitors, in which the capacitor leads serve as winding mandrels, are available from ITW Ltd, Electronic Division, of Slough. These are thought to be the first capacitors to be manufactured using this technique which eliminates outside wrapping and separate lead attachments. In consequence, the capacitors have no mandrel hole left as in conventionally wound capacitors and it is claimed that air or moisture cannot penetrate and the leads cannot loosen.

The electrode foils and lead wires are separated by three layers of dielectric, and no dielectric is in direct contact with either wire in the electrical field. This manufacturing process insures against voltage breakdown in the area of lead wire penetration. The PT polyester series covers the capacitance range 1000pF to 150nF with tolerances of ±10% to ±20% and voltage ratings of 200-400V d.c.

Completely self encased, types PT and PP capacitors provide low inductance, high insulation resistance and a low dissipation factor; additionally, the type PP has a negative temperature coefficient. ITW Ltd, Electronic Division, 263 Farnham Road, Slough, SL2 1HA.
**WW 319 for further details**

# Solid State Devices

Each section under the title of Solid State, is devoted to the new semiconductor products offered by one manufacturer or distributor. The type number and device title is given in bold type, followed by a brief description of features or application. The section is terminated with the address of the company together with reader reply card numbers associated with the device numbers or types.
Announced from Celdis Ltd:

**MC14530, dual 5-input majority logic gate.** This is a Motorola m.o.s. i.c. which sometimes is referred to as having "voting logic" since it makes decisions based upon the levels presented at its inputs. Eighteen different logic possibilities are permitted and the alternative of a number of simple or fewer complex logic functions are facilitated without resort to a high gate count. It is constructed for p and n channel enhancement mode devices and features single positive or negative power supply operation with a typical noise immunity of 45% v.d.d. and a fan out of 750.

**MC10128, MC10129, dual bus driver/quad bus receiver.** These are designed to interface with t.t.l. or I.B.M. level buses, enabling high speed mainframes to feed the slower t.t.l. peripheral equipment. Price of both devices for 100 up quantity is £0.712.

**MC1408L-8, eight-bit digital to analogue converter.** This device features a current mode output and will provide a linear product of an eight-bit digital word and an analogue input voltage. The relative accuracy is ±19% error maximum, settling time is typically 300ns, non-inverting digital inputs are t.t.l. and c.m.o.s. compatible, output voltage swing is from +0.5V to 5.0V and the multiplying input slew rate is 4.0mA/ms. Price is £3.101 each at 100 up rate.

**MC12000 digital mixer/translator.** Designed to produce an output frequency which is the difference between two input frequencies, this i.c. consists of a D flip-flop with t.t.l. to e.c.l. and e.c.l. to t.t.l. translators. Intended primarily for use as a prescaler in phase-locked loop applications where the v.c.o. frequency is greater than 10MHz and the tuning range is narrow, it provides a means of generating frequencies up to 250MHz without tuned circuits. The output frequency could be either a single fixed frequency or a series of programmable frequencies when used in conjunction with the MC4016 programmable Modulo-N decade counter. Price is £2.38 at 100 up rate.

**MC1455P1 i.c. timing circuit.** This circuit provides timing intervals from 1 $\mu$s to 1hr simply by the selection of one external resistor and capacitor. In the astable mode, it will operate as an oscillator with the frequency and duty cycle determined by the selection of two external resistors and a capacitor. The output can drive t.t.l. logic and can either sink or source up to 200mA. Price at 100 up rate, £0.55.

**MC7800 series fixed voltage regulators.** These are available in seven groups of 5, 6, 8, 12, 15, 18 and 24 volts, each able to supply over 1A with adequate heat sinking. Price (100 up) is £0.872.

**5082-4860 and 5082-4468 light emitting diodes.** These are made by Hewlett-Packard and contain a built-in resistor which acts in a current limiting mode. This makes them suitable for direct driving from t.t.l. or other i.c. families. The 5082-4860 is 0.2in diameter and is panel mounted by black plastic clips (part 5082-4418) which are supplied free of charge if ordered with the l.e.ds. The 5082-4468 has a diameter of 0.125in but has the same specification in other respects. Luminous intensity is 0.8mcd (typical) at a $V_F$ of 5V with a wave length of 655nm. Response speed is 15ns. Price (100 up) is £0.35 each for both types.

**KBS series rectifier bridges** are made by G.I., and are epoxy encapsulated inside a hexagonal metal case which is stud-mounted. With a dimension of 0.55in across flats, the devices will rectify up to 2A with a case temperature of 50°C. Voltage selections are 50, 100, 200, 400 and 600V with typical 100 up prices for say the KBS005 (50V) of £0.312 each to the KBS06 (600V) at £0.412.

**40967 and 40968 r.f. transistors** from RCA are designed for use as u.h.f. class C amplifiers in low voltage mobile applications. They are rated for 2W and 6W power output respectively, at 470MHz and a 12.5V supply. Supplied in the RCA HF-44 package, the price at 100 up quantities is £3.16 and £4.02 each respectively. Celdis Ltd, 37/39 Loverock Road, Reading, Berks RG3 1ED.
**WW 330 majority logic gate**
**WW 331 dual bus driver/quad bus receiver**
**WW 332 8-bit d/a converter**
**WW 333 digital mixer/translator**
**WW 334 i.c. timing circuit**
**WW 351 voltage regulators**
**WW 335 resistor — l.e.ds**
**WW 336 rectifier bridges**
**WW 337 r.f. transistors**

**S.010 d.c.-d.c. converter** by IPL provides dual positive and negative rails up to 15V and operates from a single 5V, t.t.l. supply rail. The dimensions are 2.48 × 1.225 × 0.575in and has a 0.1in grid connection pins. No heat sinking is required for supply currents up to 40mA at 12V and 34mA at 15V. The transient response is 10μs to 0.1% and a 15mV pk-pk output ripple. Each individual output is preset by a single resistor and each output is isolated (up to $10^{10}$MΩ) from the input. Price £10 each.

**S1724 variable 256-bit shift register.** This i.c. is made by AMI and is electrically programmable from 2 to 257 bits. It features m.o.s.-t.t.l. compatible inputs and outputs without the need for external resistors and through the use of a push-pull output will sink 1.6mA. Capable of being operated up to 1MHz, the S1724 is supplied in a 14 lead d.i.l. package at a 100 up price of £8.75.

**S1709 queueing buffer register** by AMI contains thirteen parallel in–parallel out shift registers and the control logic necessary to achieve a first in-first out (SILO) memory configuration. External control signals allow the cascading of many register arrays and the S1709 may operate with independent input and output data rates. The i.c. is a low voltage threshold m.o.s. device and packaged in a 24 lead d.i.l. package. Cost is £8.69 (100 up).

**HD-0165 keyboard encoder** from Harris is a 16-line to four-bit parallel encoder intended for use with manual data entry devices such as calculators, typewriters, etc. In addition to the encoding function there is a strobe output and a key rollover output which energizes whenever two or more inputs are activated simultaneously. These are normally routed through the key switches to the +5V supply. Price of the 24 lead d.i.l. package is £3.22 (100 up).

**AA2705 operational amplifier.** This Harris i.c. is designed to dissipate 0.75mW with dual 5.5V rails and 2.25mW with dual 15V rails. Open loop gain is 2,000,000, input offsets are 2.5nA and 1mV and the slew rate is 20V/μs. Common mode and power supply rejection ratio are both 80dB minimum and the device will deliver up to 22mA output current.

**TS6AM6. Fetron.** This Teledyne device is designed as a direct solid state valve replacement and will plug in to the 6AM6/EF91/Z77 pentode valve sockets, which it is intended to replace, without circuit modifications. Price (100 up) £4.70. GDS (Sales) Ltd, Michaelmas House, Salt Hill, Bath Road, Slough.
**WW338 d.c./d.c. converter**
**WW339 256-bit register**
**WW340 buffer register**
**WW341 keyboard encoder**
**WW342 operational amplifier**
**WW343 Fetron**

**IR106 low power thyristor range.** These devices offer a $V_{RRM}/V_{DRM}$ range of 15 to 400V and are available in five different packages which allow for p.c.b. mounting.

**IR140 and IR141 fast turn-off thyristor ranges.** Conforming to the JEDEC 2N3649 and 2N3658 series respectively, these thyristors offer a maximum turn-off time of 15μs for the IR140 and 10μs for the IR141. The re-applied dv/dt is 200V/μs for both devices and they will operate at up to 4kHz without peak current capability being reduced. International Rectifier, Hurst Green, Oxted, Surrey.
**WW344 low power thyristor range**
**WW345 fast turn-off thyristors**

**NSN-33 three-digit l.e.d. display** is a pin for pin replacement for the Litronix DL33. Each digit in the NSN-33 is 0.125in high and is made up of seven segments and a right hand decimal point. Segment and decimal point anodes of the three digits are internally connected in parallel. Current drive is 1mA average per segment to a maximum of 8mA. Packaged as a 12 pin d.i.l., the digits are spaced on 0.2in centres for end-to-end stacking of 6, 9 or 12 or more digits. The NSN-133 is a modified version of the same display with a minus sign replacing the extreme left digit and connected to pin 12 which is unused in the NSN-33. Displays are available in matched brightness sets.

**NSL5027 high intensity l.e.d.** This lamp has an intensity of 2.0mcd minimum at 10mA, a forward current ($I_F$) of 70mA d.c. and a reverse voltage of 3V with a power dissipation of 140mW. Price (100 up) is 60p.

**LHOO62 f.e.t. operational amplifier i.c.** The circuit contains a monolithic dual j.f.e.t. chip and a bipolar op-amp similar to the LM118. Typical offsets are 2mV and 1pA with an offset temperature coefficient of 5V/°C. Drifts are only 4μV and 0.1pA per week! No external components are required for operation and the i.c. offers a 15MHz bandwidth, 70V/μs slew rate and 1μs settling time to 0.1%. Feedforward compensation almost doubles the speed whilst an extra capacitor lowers the settling time. Gain is 100V/mV and noise currents are less than 0.1pA r.m.s.

**MM5316 digital alarm clock.** This is a completely self contained alarm clock circuit capable of driving fluorescent tubes or liquid crystal displays. It is a monolithic m.o.s. integrated circuit that employs both low threshold p-channel enhancement mode and ion implanted depletion mode devices. The timekeeping function is triggered either by a 50 or 60Hz input and the display format may be either 12 hrs with suppressed leading zeros and a.m. or p.m. indication or 24 hrs. Four possible display modes are offered, time in hours and minutes, minutes and seconds, alarm set time or sleep time, with outputs provided for display drives, alarm enable and sleep or timed radio turn-off. The device operates over an unregulated supply range of from 8 to 29V and is available in a 40 pin epoxy B package.

**DM7575/DM8575 and DM7576/DM8576 programmable logic array.** These arrays have 14 data inputs and 8 outputs. Each output provides a sum of product terms where each product term can contain any combination of 14 variables or their complements. The p.l.a. is intended for use as control logic in digital systems and features a typical delay of 90ns and dissipates about 550mW. The DM7575/DM8575 has a conventional totem-pole output and the DM7576/DM8576 has a passive pull-up output for use in systems requiring more than one p.l.a. The arrays are available in a 24 pin Epoxy B d.i.l. package for operation from 0°C to 70°C (DM8575 and DM8576) or a 24 pin ceramic d.i.p. for operation over −55°C to 125°C temperature range (DM7575 and DM7576). National Semiconductor (UK) Ltd, The Precinct, Broxbourne, Herts.
**WW 346 l.e.d. display**
**WW347 high intensity l.e.d.**
**WW348 f.e.t. operational amplifier**
**WW349 alarm clock i.c.**
**WW350 programmable logic array**

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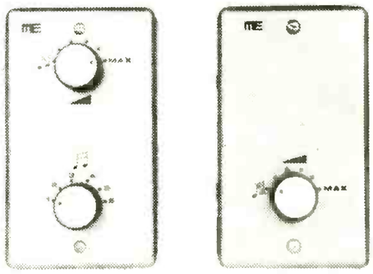

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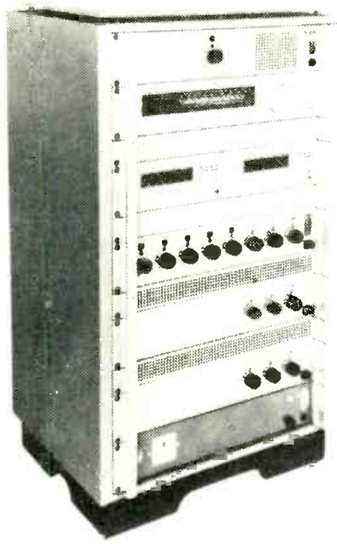

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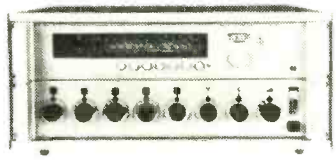

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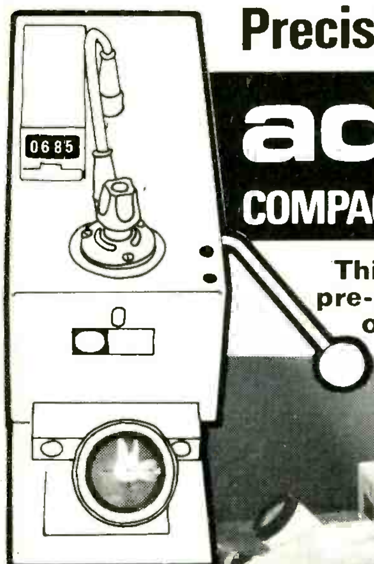


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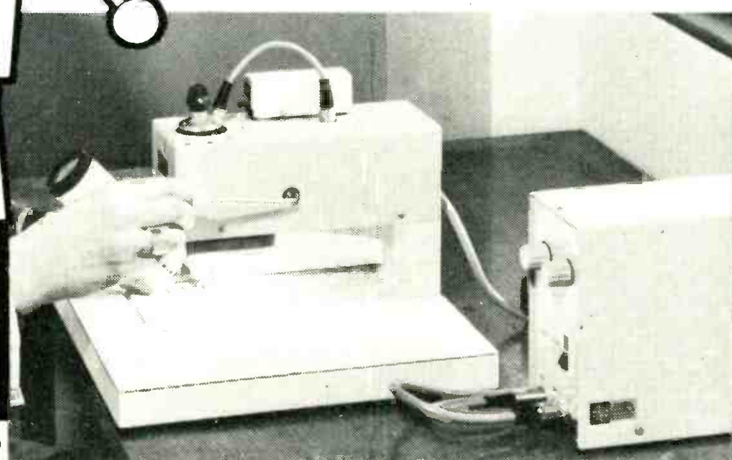

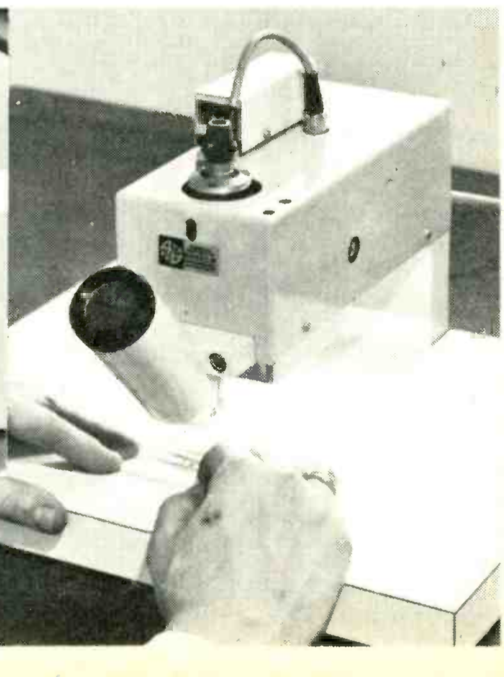

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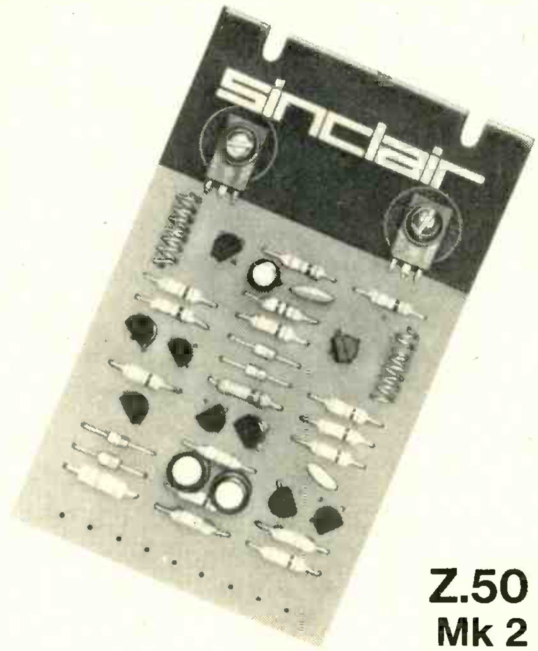
# Sinclair Project 60

# New performance standards ... new safety margins




**Z.50 Mk 2**

Such are the results of using a PZ8 Mk.3 to drive two Z.50 Mk.2 power amplifiers. Developed from the original Z.50, the Mk.2 has improved thermal stability, better regulated D.C. limiting to ensure more symmetrical output voltage swing with still less distortion at lower outputs and automatic transient overload protection. The PZ.8 Mk.3 is the most advanced power supply unit ever to be made at a reasonable price. It cannot be damaged by direct shorting, nor will it fail through overloading, because of an ingenious re-entrant current limiting principle used usually only in expensive laboratory equipment. Because output voltage is variable, the PZ8 Mk.3 makes a worthwhile alternative where PZ.5 and PZ.6 are recommended for Project 60 applications, particularly since this most powerful of all Sinclair supply units can be operated from a smaller mains transformer. Together, the Z.50 Mk.2 and PZ8 Mk.3 provide new standards of performance and reliability and these modules are compatible with earlier types in the Project 60 range.

Z.50 Mk.2 SPECIFICATIONS

Input impedance 100 KΩ
Input (for 30w into 8Ω) 400mV
Signal to noise ratio, referred to full o/p at 30v HT 80dB or better
Distortion 0.02% up to 20W at 8Ω. See published curve
Frequency response 10Hz to more than 200 KHz ± 1dB
Max. supply voltage 45v (4Ω to 8Ω speakers) (50v 15Ω speakers only)
Min. supply voltage 9v
Load impedance – minimum: 4Ω at 45v HT
Load impedance – maximum: safe on open circuit

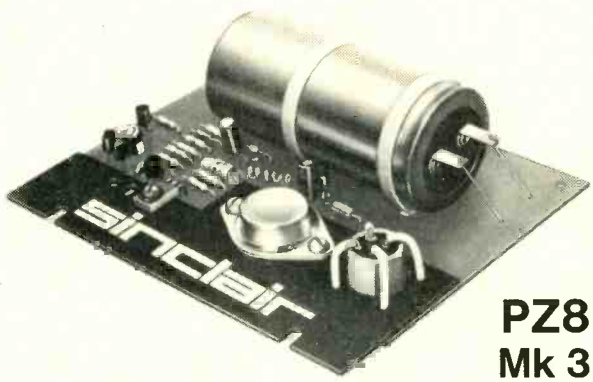
£5.48 + V.A.T. 54p

PZ.8 Mk.3 SPECIFICATIONS

Nominal working output 45V.
Adjustable between 20 & 50V.

£7.98 + V.A.T. 79p

*Mains Transformer* £5.98 + V.A.T. 59p




**PZ8 Mk 3**

## Other power supplies

In addition to the remarkable Sinclair PZ.8 Mk.III as described, there are two other power units available, which should be chosen according to their types in order to buy to best advantage. All are for operation from A.C. mains 240V.

PZ.5 30 volt, unstabilised **£4.98** + V.A.T. 49p

PZ.6 35 volt, stabilised (Not suitable for Super IC.12). **£7.98** + V.A.T. 79p

## Guarantee

If, within 3 months of purchasing any product direct from Sinclair Radionics Ltd., you are dissatisfied with it, your money will be refunded at once. Many Sinclair appointed Stockists also offer this same guarantee in co-operation with Sinclair Radionics Ltd.

Each Project 60 module is tested before leaving our factory and guaranteed to work perfectly. Should any defect arise in normal use, we will service it at once and without any charge to you. A small charge may be made in those cases where damage arises through miss-use. No charge is made for postage by surface mail. Air Mail charged at cost.

## Typical Project 60 applications

| System | The Units to use | together with | Units cost |
|---|---|---|---|
| Simple battery record player | **Z.50** | Crystal P.U., 12V battery volume control, etc. | **£5.48** + V.A.T. 54p |
| Mains powered record player | **Z.50, PZ.5** | Crystal or ceramic P.U. volume control, etc. | **£10.46** + V.A.T. £1.04 |
| 12W. RMS continuous sine wave stereo amp. for average needs | **2 x Z.50, Stereo 60; PZ.5** | Crystal, ceramic or mag. P.U., F.M. Tuner, etc. | **£25.92** + V.A.T. £2.59 |
| 25W. RMS continuous sine wave stereo amp. using low efficiency (high performance) speakers | **2 x Z.50, Stereo 60; PZ.6** | High quality ceramic or magnetic P.U., F.M. Tuner, Tape Deck, etc. | **£28.92** + V.A.T. £2.89 |
| 80W. (3 ohms) RMS continuous sine wave de luxe stereo amplifier. (60W. RMS into 8 ohms) | **2 x Z.50 Mk.2, Stereo 60; PZ.8 Mk.3 transformer** | As above | **£34.90** + V.A.T. £3.49 |
| Indoor P.A. | **Z.50 Mk.2, PZ.8 Mk.3 transformer** | Mic., guitar, speakers, etc., controls | **£19.44** + V.A.T. £1.94 |

A.F.U. (**£5.98** + V.A.T. 59p) may be added as required.

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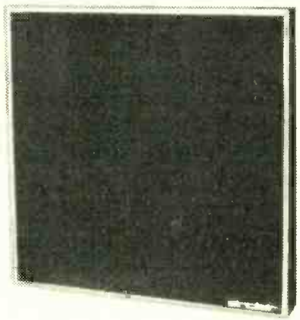
# the world's most advanced high fidelity modules

## Q.16 high fidelity loudspeaker



The Q 16 employs original and by now well proven acoustic principles in which a special driver assembly is meticulously matched to a uniquely designed cabinet. In performance it comfortably stands comparison with very much more expensive loudspeakers. A solid teak surround is used with a special all-over cellular black foam front chosen both for its appearance and ability to pass all audio frequencies without masking.

**Specifications**
Construction: A sealed seamless sound or pressure chamber is used with internal baffle, and special high flux driver
Loading: Up to 14 watts RMS, into 8 ohms
Frequency response: From 60 to 16,000 Hz
Size and styling: 248 mm square x 120 mm deep (9¾" x 4¾") with neat pedestal base.

**£7.70** + V.A.T. 77p


## Stereo 60 pre-amp/control unit

Designed specifically for Project 60 systems, the Stereo 60 is equally suitable with any high quality power amplifier. Silicon epitaxial planar transistors used throughout ensure high signal-to-noise ratio and excellent tracking between channels. Input selection is by press buttons, with accurate equalisation on all input channels. The unit is easy to mount.

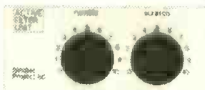
**SPECIFICATIONS—Input sensitivities:** Radio – up to 3mV. Mag. p.u. 3mV: correct to R.I.A.A. curve ±1dB: 20 to 25,000Hz. Ceramic p.u. – up to 3mV: Aux – up to 3mV. **Output:** 250mV. **Signal to noise ratio:** better than 70dB. **Channel matching:** within 1dB. **Tone controls:** TREBLE +12 to —12dB at 10KHz: BASS +12 to —12dB at 100Hz. **Front panel:** brushed aluminium with black knobs and controls. **Size:** 66 × 40 × 207mm.

*Built, tested and guaranteed.* **£9.98** + V.A.T. 99p

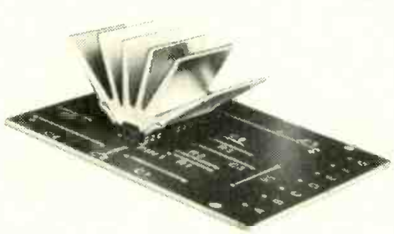
## AFU filter unit

For use between Stereo 60 and two Z 30's or Z 50's in stereo formation. Cut off frequencies are continuously variable, with 12dB/octave cut in the rejection band. Two stages of filtering – rumble (high pass) and scratch (low pass). Amplitude and phase distortion are negligible. Supply voltage needed – 15–35V. H.F. cut-off (—3dB) 28KHz to 5KHz: L.F. (—3dB) 25Hz to 100Hz. For Project 60 or any good stereo system. Built, tested and guaranteed

**£5.98** + V.A.T. 59p



## Super IC.12 Integrated circuit high fidelity amplifier



Having introduced Integrated Circuits to hi-fi constructors with the IC.10, which was the first time an IC had ever been made available for such purposes, we followed it with an even more efficient version, the Super IC.12. This needs very few external resistors and capacitors to make an exceedingly efficient high fidelity amplifier for pick-up, F.M. radio or small P.A. set up etc. The free 40 page manual supplied details many other applications which this remarkable IC make possible. The Super IC.12 is the equivalent of a 22 transistor circuit contained within a 16 lead DIL package, and the finned heat sink is sufficient for all likely requirements. The Super IC.12 is also compatible with those Project 60 modules which would be used with the Z.50 and Z.30 amplifiers. Complete with free manual and printed circuit board.

**SPECIFICATIONS**
**Output power:** 6 watts RMS continuous (12 watts peak) into 6–8 Ω. **Frequency Response:** 5Hz to 100KHz ±1dB. **Total Harmonic Distortion:** Less than 1%. (Typical 0.1%) at all output powers and frequencies in the audio band (28V). **Load Impedance:** 3 to 15 ohms. **Input Impedance:** 250 Kohms nominal. **Power Gain:** 90dB (1,000,000,000 times) after feedback. **Supply Voltage:** 6 to 28V. **Quiescent current:** 8mA at 28V. **Size:** 22 × 45 × 28mm including pins and heat sink.

*Manual available separately 15p post free*

With FREE printed circuit board and 40 page manual.

**£2.98** + V.A.T. 29p Post free

## Project 605


### the simple way to build a Project 60 system without soldering

For the many audio enthusiasts anxious to build to high standards without too many involvements, there could be nothing better or simpler than Project 605. It offers the advantages of Project 60 and is absolutely complete down to the last piece of wire cut to length. Whilst not as powerful as assemblies using Z.50 power amplifiers, we know from experience that there are many for whom the specifications of Project 605 are ideal, particularly in relation to the environment in which it is required to be used. In Project 605 you have everything necessary to build a versatile Project 60 thirty watt high fidelity amplifier system suitable for all domestic requirements. The convenient pack includes two Z.30 power amplifiers, a Stereo 60 pre-amp control unit and the special Masterlink unit to and from which all input and output connections are made. For power a PZ.5 is provided. Building is particularly easy since all necessary leads are supplied colour coded, cut to length and terminated by contact clips which connect firmly to the modules. There is absolutely no soldering to be done. Complete with comprehensive, easy to follow instructions manual.

**£29.95** + V.A.T. £2.99 Post free

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| AC127 | 0·19 |
| AC128 | 0·19 |
| AC132 | 0·16 |
| AC134 | 0·16 |
| AC137 | 0·16 |
| AC141 | 0·16 |
| AC141K | 0·19 |
| AC142 | 0·16 |
| AC142K | 0·19 |
| AC151 | 0·17 |
| AC154 | 0·22 |
| AC155 | 0·22 |
| AC156 | 0·22 |
| AC157 | 0·27 |
| AC165 | 0·22 |
| AC166 | 0·22 |
| AC167 | 0·22 |
| AC168 | 0·27 |
| AC169 | 0·16 |
| AC176 | 0·22 |
| AC177 | 0·27 |
| AC178 | 0·31 |
| AC179 | 0·31 |
| AC180 | 0·19 |
| AC180K | 0·22 |
| AC181 | 0·19 |
| AC181K | 0·22 |
| AC187 | 0·24 |
| AC187K | 0·22 |
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| AC188K | 0·22 |
| ACY17 | 0·28 |
| ACY18 | 0·22 |
| ACY19 | 0·22 |
| ACY20 | 0·22 |
| ACY21 | 0·22 |
| ACY22 | 0·18 |
| ACY27 | 0·20 |
| ACY28 | 0·21 |
| ACY29 | 0·39 |
| ACY30 | 0·31 |
| ACY31 | 0·31 |
| ACY34 | 0·23 |
| ACY35 | 0·23 |
| ACY36 | 0·31 |
| ACY40 | 0·19 |
| ACY41 | 0·20 |
| ACY44 | 0·39 |
| AD130 | 0·42 |
| AD140 | 0·53 |
| AD142 | 0·53 |
| AD143 | 0·43 |
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| AD162 | 0·37 |
| AD161 & AD162 (MP) | 0·61 |
| ADT140 | 0·55 |
| AF114 | 0·27 |
| AF115 | 0·27 |
| AF116 | 0·27 |
| AF117 | 0·27 |
| AF118 | 0·39 |
| AF124 | 0·33 |
| AF125 | 0·28 |
| AF126 | 0·31 |
| AF127 | 0·31 |
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| AF181 | 0·50 |
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| AF239 | 0·41 |
| AL102 | 0·72 |
| AL103 | 0·72 |
| ASY26 | 0·28 |
| ASY27 | 0·33 |
| ASY28 | 0·28 |
| ASY29 | 0·28 |
| ASY50 | 0·28 |
| ASY51 | 0·28 |
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| ASY56 | 0·28 |
| ASY57 | 0·28 |
| ASY58 | 0·28 |
| ASZ21 | 0·44 |
| BC107 | 0·10 |
| BC108 | 0·10 |
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| BC113 | 0·11 |
| BC114 | 0·17 |
| BC115 | 0·17 |
| BC116 | 0·17 |
| BC117 | 0·17 |
| BC118 | 0·11 |
| BC119 | 0·33 |
| BC120 | 0·88 |
| BC125 | 0·13 |
| BC126 | 0·20 |
| BC132 | 0·13 |
| BC134 | 0·20 |
| BC135 | 0·13 |
| BC136 | 0·17 |
| BC137 | 0·17 |
| BC139 | 0·44 |
| BC140 | 0·33 |
| BC141 | 0·33 |
| BC142 | 0·33 |
| BC143 | 0·33 |
| BC145 | 0·50 |
| BC147 | 0·11 |

| Type | Price |
|---|---|
| BC148 | 0·11 |
| BC149 | 0·13 |
| BC150 | 0·20 |
| BC151 | 0·22 |
| BC152 | 0·19 |
| BC153 | 0·31 |
| BC154 | 0·33 |
| BC157 | 0·20 |
| BC158 | 0·13 |
| BC159 | 0·13 |
| BC160 | 0·50 |
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| BC207 | 0·12 |
| BC208 | 0·12 |
| BC209 | 0·13 |
| BC212L | 0·12 |
| BC213L | 0·12 |
| BC214L | 0·16 |
| BC225 | 0·28 |
| BC226 | 0·39 |
| BCY30 | 0·27 |
| BCY31 | 0·29 |
| BCY32 | 0·33 |
| BCY33 | 0·24 |
| BCY34 | 0·28 |
| BCY70 | 0·16 |
| BCY71 | 0·20 |
| BCY72 | 0·16 |
| BCZ10 | 0·22 |
| BCZ11 | 0·28 |
| BCX12 | 0·28 |
| BD121 | 0·66 |
| BD123 | 0·72 |
| BD124 | 0·66 |
| BD131 | 0·55 |
| BD132 | 0·66 |
| BD133 | 0·72 |
| BD135 | 0·44 |

| Type | Price |
|---|---|
| BD136 | 0·44 |
| BD137 | 0·50 |
| BD138 | 0·55 |
| BD139 | 0·61 |
| BD140 | 0·66 |
| BD155 | 0·88 |
| BD175 | 0·66 |
| BD176 | 0·66 |
| BD177 | 0·72 |
| BD178 | 0·72 |
| BD179 | 0·77 |
| BD180 | 0·77 |
| BD185 | 0·83 |
| BD186 | 0·72 |
| BD187 | 0·77 |
| BD188 | 0·77 |
| BD189 | 0·99 |
| BD190 | 0·83 |
| BD195 | 0·94 |
| BD196 | 0·94 |
| BD197 | 0·99 |
| BD198 | 0·99 |
| BD199 | 1·05 |
| BD200 | 1·05 |
| BD205 | 0·88 |
| BD206 | 0·88 |
| BD207 | 1·05 |
| BD208 | 1·05 |
| BDY20 | 1·10 |
| BF115 | 0·27 |
| BF117 | 0·50 |
| BF118 | 0·77 |
| BF119 | 0·77 |
| BF121 | 0·50 |
| BF123 | 0·55 |
| BF125 | 0·50 |
| BF127 | 0·55 |
| BF152 | 0·61 |
| BF153 | 0·50 |
| BF154 | 0·50 |
| BF155 | 0·77 |
| BF156 | 0·53 |
| BF157 | 0·61 |
| BF158 | 0·61 |
| BF159 | 0·66 |
| BF160 | 0·44 |
| BF162 | 0·44 |
| BF163 | 0·44 |
| BF164 | 0·44 |
| BF165 | 0·44 |
| BF167 | 0·24 |
| BF173 | 0·24 |
| BF176 | 0·34 |
| BF177 | 0·39 |
| BF178 | 0·33 |
| BF179 | 0·33 |
| BF180 | 0·33 |
| BF181 | 0·33 |
| BF182 | 0·44 |
| BF183 | 0·44 |
| BF184 | 0·28 |

| Type | Price |
|---|---|
| BF185 | 0·33 |
| BF188 | 0·44 |
| BF194 | 0·13 |
| BF195 | 0·13 |
| BF196 | 0·16 |
| BF197 | 0·16 |
| BF200 | 0·50 |
| BF222 | 1·05 |
| BF257 | 0·50 |
| BF258 | 0·66 |
| BF259 | 0·94 |
| BF292 | 0·61 |
| BF263 | 0·61 |
| BF270 | 0·39 |
| BF271 | 0·33 |
| BF272 | 0·38 |
| BF273 | 0·39 |
| BF274 | 0·39 |
| BFW10 | 0·66 |
| BFX29 | 0·30 |
| BFX84 | 0·24 |
| BFX85 | 0·33 |
| BFX86 | 0·24 |
| BFX87 | 0·27 |
| BFX88 | 0·24 |
| BFY50 | 0·22 |
| BFY51 | 0·22 |
| BFY52 | 0·22 |
| BFY53 | 0·19 |
| BPX25 | 0·94 |
| BSX19 | 0·17 |
| BSX20 | 0·17 |
| BSY25 | 0·17 |
| BSY26 | 0·17 |
| BSY27 | 0·17 |
| BSY28 | 0·17 |
| BSY29 | 0·17 |
| BSY38 | 0·20 |
| BSY39 | 0·20 |
| BSY40 | 0·31 |
| BSY41 | 0·31 |
| BSY95 | 0·14 |
| BSY95A | 0·14 |
| Bu105 | 2·20 |
| C111E | 0·55 |
| C400 | 0·33 |
| C407 | 0·28 |
| C424 | 0·22 |
| C425 | 0·55 |
| C426 | 0·39 |
| C428 | 0·22 |
| C441 | 0·33 |
| C442 | 0·33 |
| C444 | 0·39 |
| C450 | 0·24 |
| MAT100 | 0·21 |
| MAT101 | 0·22 |
| MAT120 | 0·21 |
| MAT121 | 0·20 |
| MPF102 | 0·46 |
| MPF104 | 0·41 |

| Type | Price |
|---|---|
| MPF105 | 0·41 |
| OC19 | 0·39 |
| OC20 | 0·70 |
| OC22 | 0·42 |
| OC23 | 0·46 |
| OC24 | 0·62 |
| OC25 | 0·42 |
| OC26 | 0·28 |
| OC28 | 0·55 |
| OC29 | 0·55 |
| OC35 | 0·46 |
| OC36 | 0·55 |
| OC41 | 0·22 |
| OC42 | 0·27 |
| OC44 | 0·17 |
| OC45 | 0·14 |
| OC70 | 0·11 |
| OC71 | 0·11 |
| OC72 | 0·16 |
| OC74 | 0·16 |
| OC75 | 0·17 |
| OC76 | 0·17 |
| OC77 | 0·28 |
| OC81 | 0·17 |
| OC81D | 0·17 |
| OC82 | 0·17 |
| OC82D | 0·17 |
| OC83 | 0·22 |
| OC84 | 0·22 |
| OC139 | 0·22 |
| OC140 | 0·22 |
| OC169 | 0·28 |
| OC170 | 0·28 |
| OC171 | 0·28 |
| OC200 | 0·28 |
| OC201 | 0·31 |
| OC202 | 0·31 |
| OC203 | 0·28 |
| OC204 | 0·28 |
| OC205 | 0·39 |
| OC309 | 0·44 |
| OCP71 | 0·48 |
| ORP12 | 0·48 |
| ORP60 | 0·44 |
| ORP61 | 0·44 |
| P346A | 0·22 |
| P397 | 0·46 |
| ST140 | 0·46 |
| ST140 | 0·14 |
| ST141 | 0·19 |
| TIS43 | 0·33 |
| UT46 | 0·30 |
| 2G301 | 0·21 |
| 2G302 | 0·21 |
| 2G303 | 0·21 |
| 2G304 | 0·27 |
| 2G306 | 0·44 |
| 2G308 | 0·39 |
| 2G309 | 0·39 |
| 2G339 | 0·22 |
| 2G339A | 0·18 |

| Type | Price |
|---|---|
| 2G344 | 0·20 |
| 2G345 | 0·18 |
| 2G371 | 0·18 |
| 2G371B | 0·13 |
| 2G373 | 0·19 |
| 2G374 | 0·19 |
| 2G377 | 0·33 |
| 2G378 | 0·18 |
| 2G381 | 0·18 |
| 2G382 | 0·18 |
| 2G401 | 0·33 |
| 2G414 | 0·33 |
| 2G417 | 0·28 |
| 2N388 | 0·39 |
| 2N388A | 0·61 |
| 2N404 | 0·22 |
| 2N404A | 0·31 |
| 2N524 | 0·46 |
| 2N527 | 0·54 |
| 2N598 | 0·46 |
| 2N599 | 0·50 |
| 2N696 | 0·14 |
| 2N697 | 0·15 |
| 2N698 | 0·27 |
| 2N699 | 0·39 |
| 2N706 | 0·09 |
| 2N706A | 0·10 |
| 2N708 | 0·13 |
| 2N711 | 0·33 |
| 2N717 | 0·39 |
| 2N718 | 0·27 |
| 2N718A | 0·55 |
| 2N726 | 0·31 |
| 2N727 | 0·31 |
| 2N743 | 0·22 |
| 2N744 | 0·22 |
| 2N914 | 0·16 |
| 2N918 | 0·33 |
| 2N929 | 0·23 |
| 2N930 | 0·23 |
| 2N1131 | 0·22 |
| 2N1132 | 0·24 |
| 2N1302 | 0·16 |
| 2N1303 | 0·16 |
| 2N1304 | 0·19 |
| 2N1305 | 0·19 |
| 2N1306 | 0·23 |
| 2N1307 | 0·23 |
| 2N1308 | 0·26 |
| 2N1309 | 0·26 |
| 2N1613 | 0·22 |
| 2N1711 | 0·22 |
| 2N1889 | 0·35 |
| 2N1890 | 0·50 |
| 2N1893 | 0·41 |
| 2N2147 | 0·79 |
| 2N2148 | 0·63 |
| 2N2160 | 0·66 |
| 2N2192 | 0·39 |
| 2N2193 | 0·39 |
| 2N2194 | 0·39 |

| Type | Price |
|---|---|
| 2N2217 | 0·24 |
| 2N2218 | 0·22 |
| 2N2219 | 0·22 |
| 2N2220 | 0·24 |
| 2N2221 | 0·22 |
| 2N2222 | 0·22 |
| 2N2368 | 0·19 |
| 2N2369 | 0·16 |
| 2N2369A | 0·16 |
| 2N2411 | 0·27 |
| 2N2412 | 0·27 |
| 2N2646 | 0·52 |
| 2N2711 | 0·23 |
| 2N2712 | 0·23 |
| 2N2714 | 0·23 |
| 2M2904 | 0·19 |
| 2N2904A | 0·23 |
| 2N2905 | 0·23 |
| 2N2905A | 0·23 |
| 2N2906 | 0·17 |
| 2N2906A | 0·20 |
| 2N2907 | 0·22 |
| 2N2907A | 0·24 |
| 2N2923 | 0·16 |
| 2N2924 | 0·16 |
| 2N2925 | 0·16 |
| 2N2926(G) | 0·14 |
| 2N2926(Y) | 0·12 |
| 2N2926(O) | 0·11 |
| 2N2926(R) | 0·11 |
| 2N2926(B) | 0·11 |
| 2N3010 | 0·77 |
| 2N3011 | 0·16 |

| Type | Price |
|---|---|
| 2N3053 | 0·19 |
| 2N3054 | 0·51 |
| 2N3055 | 0·55 |
| 2N3391 | 0·16 |
| 2N3391A | 0·18 |
| 2N3392 | 0·16 |
| 2N3393 | 0·16 |
| 2N3394 | 0·16 |
| 2N3395 | 0·19 |
| 2N3402 | 0·23 |
| 2N3403 | 0·23 |
| 2N3404 | 0·31 |
| 2N3405 | 0·46 |
| 2N3414 | 0·17 |
| 2N3415 | 0·17 |
| 2N3416 | 0·31 |
| 2N3417 | 0·31 |
| 2N3525 | 0·83 |
| 2N3646 | 0·10 |
| 2N3702 | 0·11 |
| 2N3703 | 0·11 |
| 2N3704 | 0·12 |
| 2N3705 | 0·11 |
| 2N3706 | 0·10 |
| 2N3707 | 0·12 |
| 2N3708 | 0·08 |
| 2N3709 | 0·10 |
| 2N3710 | 0·10 |
| 2N3711 | 0·10 |
| 2N3819 | 0·31 |
| 2N3820 | 0·55 |
| 2N3821 | 0·39 |
| 2N3823 | 0·31 |
| 2N3903 | 0·31 |
| 2N3904 | 0·33 |
| 2N3905 | 0·31 |
| 2N3906 | 0·30 |
| 2N4058 | 0·13 |

| Type | Price |
|---|---|
| 2N4059 | 0·11 |
| 2N4060 | 0·13 |
| 2N4061 | 0·13 |
| 2N4062 | 0·13 |
| 2N4284 | 0·19 |
| 2N4285 | 0·19 |
| 2N4286 | 0·19 |
| 2N4287 | 0·19 |
| 2N4288 | 0·19 |
| 2N4289 | 0·19 |
| 2N4290 | 0·19 |
| 2N4291 | 0·19 |
| 2N4292 | 0·19 |
| 2N4293 | 0·19 |
| 2N5172 | 0·13 |
| 2N5457 | 0·35 |
| 2N5458 | 0·35 |
| 2N5459 | 0·44 |
| 2S301 | 0·55 |
| 2S302A | 0·46 |
| 2S302 | 0·46 |
| 2S303 | 0·61 |
| 2S304 | 0·77 |
| 2S305 | 0·93 |
| 2S306 | 0·93 |
| 2S307 | 0·93 |
| 2S321 | 0·62 |
| 2S322 | 0·46 |
| 2S322A | 0·46 |
| 2S323 | 0·62 |
| 2S324 | 0·77 |
| 2S325 | 0·77 |
| 2S326 | 0·77 |
| 2S327 | 0·77 |
| 2S701 | 0·46 |
| 40361 | 0·44 |
| 40362 | 0·50 |

### DIODES AND RECTIFIERS

| | | | | | |
|---|---|---|---|---|---|
| AA119 | 0·09 | BY133 | 0·23 | OA10 | 0·39 |
| AA120 | 0·09 | BY164 | 0·55 | OA47 | 0·08 |
| AA129 | 0·09 | BYX38/30 | | OA70 | 0·08 |
| AAY30 | 0·10 | | 0·46 | OA79 | 0·08 |
| AAZ13 | 0·11 | BYZ10 | 0·39 | OA81 | 0·08 |
| BA100 | 0·11 | BYZ11 | 0·33 | OA85 | 0·10 |
| BA116 | 0·23 | BYZ12 | 0·33 | OA90 | 0·07 |
| BA126 | 0·24 | BYZ13 | 0·28 | OA91 | 0·07 |
| BA148 | 0·16 | BYZ16 | 0·44 | OA95 | 0·08 |
| BA154 | 0·13 | BYZ17 | 0·39 | OA200 | 0·07 |
| BA155 | 0·16 | BYZ18 | 0·39 | OA202 | 0·08 |
| BA156 | 0·15 | BYZ19 | 0·31 | SD10 | 0·06 |
| BY100 | 0·17 | CG62 | | SD19 | 0·06 |
| BY101 | 0·13 | (OA91 Eq.) | | 1N34 | 0·8 |
| BY105 | 0·19 | | 0·06 | 1N34A | 0·08 |
| BY114 | 0·13 | CG651 | | 1N914 | 0·07 |
| BY126 | 0·16 | (OA70-OA79 | | 1N916 | 0·07 |
| BY127 | 0·17 | Eq.) | 0·07 | 1N414B | 0·07 |
| BY128 | 0·17 | OA5 | 0·39 | 1S021 | 0·11 |
| BY130 | 0·18 | OA58L | 0·23 | 1S951 | 0·07 |

**FULL RANGE OF ZENER DIODES VOLTAGE RANGE**
2-23V. 400mV (DO-7 Case) 15p ea. 1¼W (Top-Hat) 20p ea. 10W (SO-10 Stud) 33p ea. All fully tested 5% tol. and marked. State voltage required.

**10 amp POTTED BRIDGE RECTIFIER on heat sink. 100PIV. 99p each**

**NEW LINE**
Plastic Encapsulated
2 Amp. BRIDGE RECTS.

| | | |
|---|---|---|
| 50v RMS | 35p | each |
| 100v RMS | 41p | ,, |
| 400v RMS | 51p | ,, |

Size 15 mm × 6 mm.

**UNIJUNCTION**
UT46. Eqvt. 2N2646. Eqvt. TIS43. BEN3000 30p each, 25-99 28p 100 UP 22p.

## CADMIUM CELLS

ORP12 48p
ORP60, ORP61 44p each

**GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8. BSY-27/28/95A.** A.L.L usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

| | | £p |
|---|---|---|
| 20 | For | 0·55 |
| 50 | For | 1·10 |
| 100 | For | 1·92 |
| 500 | For | 8·25 |
| 1000 | For | 14·30 |

**SIL. G.P. DIODES £p**

| | | |
|---|---|---|
| 300mW | 30 | 0·55 |
| 40PIV(Min.) | 100 | 1·65 |
| Sub-Min. | 500 | 5·50 |
| Full Tested | 1,000 | 9·90 |

Ideal for Organ Builders.

## KING OF THE PAKS Unequalled Value and Quality

# SUPER PAKS NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

| Pak No. | | Description | Price |
|---|---|---|---|
| U 1 | 120 | Glass Sub-Min. General Purpose Germanium Diodes | 0·55 |
| U 2 | 60 | Mixed Germanium Transistors AF/RF | 0·55 |
| U 3 | 75 | Germanium Gold Bonded Sub-Min. like OA5, OA47 | 0·55 |
| U 4 | 40 | Germanium Transistors like OC81, AC128 | 0·55 |
| U 5 | 60 | 200mA Sub-Min. Silicon Diodes | 0·55 |
| U 6 | 30 | Sil. Planar Trans. NPN like BSY95A, 2N706 | 0·55 |
| U 7 | 16 | Sil. Rectifiers TOP-HAT 750mA VLTG. RANGE up to 1000 | 0·55 |
| U 8 | 50 | Sil. Planar Diodes DO-7 Glass 250mA like OA200/202 | 0·55 |
| U 9 | 20 | Mixed Voltages, 1 Watt Zener Diodes | 0·55 |
| U10 | 20 | BAY50 charge storage Diodes DO-7 Glass | 0·55 |
| U11 | 25 | PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904 | 0·55 |
| U12 | 12 | Silicon Rectifiers Epoxy 500mA up to 800 PIV | 0·55 |
| U13 | 30 | PNP-NPN Sil. Transistors OC200 & 2S 104 | 0·55 |
| U14 | 150 | Mixed Silicon and Germanium Diodes | 0·55 |
| U15 | 25 | NPN Sil. Planar Trans. TO-5 like BFY51, 2N697 | 0·55 |
| U16 | 10 | 3 Amp Silicon Rectifiers Stud Type up to 1000PIV | 0·55 |
| U17 | 30 | Germanium PNP AF Transistors TO-5 like ACY 17-22 | 0·55 |
| U18 | 8 | 6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV | 0·55 |
| U19 | 25 | Silicon NPN Transistors like BC108 | 0·55 |
| U20 | 12 | 1·5 Amp Silicon Rectifiers Top Hat up to 1000 PIV | 0·55 |
| U21 | 30 | AF. Germanium Alloy Transistors 2G300 Series & OC71 | 0·55 |
| U23 | 30 | MADT's like MHz Series PNP Transistors | 0·55 |
| U24 | 20 | Germanium 1 Amp Rectifiers GJM Series up to 300 PIV | 0·55 |
| U25 | 25 | 300 MHz NPN Silicon Transistors 2N708, BSY27 | 0·55 |
| U26 | 30 | Fast Switching Silicon Diodes like 1N914 Micro-Min. | 0·55 |
| U27 | 12 | NPN Germanium AF Transistors TO-1 like AC127 | 0·55 |
| U29 | 10 | 1 Amp SCR's TO-5 can. up to 600 PIV CRS1/25-600 | 1·10 |
| U30 | 15 | Plastic Silicon Planar Trans. NPN 2N2926 | 0·55 |
| U31 | 20 | Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707 | 0·55 |
| U32 | 25 | Zener Diodes 400mW DO-7 case 3-18 volts mixed | 0·55 |
| U33 | 15 | Plastic Case 1 Amp Silicon Rectifiers 1N4000 Series | 0·55 |
| U34 | 30 | Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4 | 0·55 |
| U35 | 25 | Silicon Planar Transistors PNP TO-18 2N2906 | 0·55 |
| U36 | 25 | Silicon Planar NPN Transistors TO-5 BFY50/51/52 | 0·55 |
| U37 | 30 | Silicon Alloy Transistors SO-2 PNP OC200, 2S322 | 0·55 |
| U38 | 20 | Fast Switching Silicon Trans. NPN 400MHz 2N3011 | 0·55 |
| U39 | 30 | RF. Germ. PNP Transistors 2N1303/5 TO-5 | 0·55 |
| U40 | 10 | Dual Transistors 6 lead TO-5 2N2060 | 0·55 |
| U41 | 25 | RF Germanium Transistors TO-5, OC45, NKT72 | 0·55 |
| U42 | 10 | VHF Germanium PNP Transistor TO-1 NKT667, AF117 | 0·55 |
| U43 | 25 | Sil. Trans. Plastic TO-18 A.F. BC113/114 | 0·55 |
| U44 | 20 | Sil. Trans. Plastic TO-5 BC115/NPN | 0·55 |
| U45 | 7 | 3A SCR. TO66 up to 600PIV | 1·10 |

Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

### QUALITY TESTED SEMICONDUCTORS

| Pak No. | | | Price £p |
|---|---|---|---|
| Q1 | 20 | Red spot transistors PNP | 0·55 |
| Q2 | 16 | White spot R.F. transistors PNP | 0·55 |
| Q3 | 4 | OC 77 type transistors | 0·55 |
| Q4 | 6 | Matched transistors OC44/45/81/81D | 0·55 |
| Q5 | 4 | OC 75 transistors | 0·55 |
| Q6 | 5 | OC 72 transistors | 0·55 |
| Q7 | 4 | AC 128 transistors PNP high gain | 0·55 |
| Q8 | 4 | AC 126 transistors PNP | 0·55 |
| Q9 | 7 | OC 81 type transistors | 0·55 |
| Q10 | 7 | OC 71 type transistors | 0·55 |
| Q11 | 2 | AC 127/128 Complementary pairs PNP/NPN | 0·55 |
| Q12 | 3 | AF 116 type transistors | 0·55 |
| Q13 | 3 | AF 117 type transistors | 0·55 |
| Q14 | 3 | OC 171 H.F. type transistors | 0·55 |
| Q15 | 7 | 2N2926 Sil. Epoxy transistors mixed colours | 0·55 |
| Q16 | 2 | GET880 low noise Germanium transistors | 0·55 |
| Q17 | 5 | NPN 2 × ST.141 & 3 × ST.140 | 0·55 |
| Q18 | 4 | MADT'S 2 × MAT 100 & 2 × MAT 120 | 0·55 |
| Q19 | 3 | MADT'S 2 × MAT 101 & 1 × MAT 121 | 0·55 |
| Q20 | 4 | OC 44 Germanium transistors A.F. | 0·55 |
| Q21 | 4 | AC 127 NPN Germanium transistors | 0·55 |
| Q22 | 20 | NKT transistors A.F. R.F. coded | 0·55 |
| Q23 | 10 | OA 202 Silicon diodes sub-min. | 0·55 |
| Q24 | 8 | OA 81 diodes | 0·55 |
| Q25 | 15 | 1N914 Silicon diodes 75 PIV 75mA | 0·55 |
| Q26 | 8 | OA95 Germanium diodes sub-min. 1N69 | 0·55 |
| Q27 | 2 | 10A PIV Silicon rectifiers IS425R | 0·55 |
| Q28 | 2 | Silicon power rectifiers BYZ 13 | 0·55 |
| Q29 | 4 | Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698 | 0·55 |
| Q30 | 7 | Silicon switch transistors 2N706 NPN | 0·55 |
| Q31 | 6 | Silicon switch transistors 2N708 NPN | 0·55 |
| Q32 | 3 | PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132 | 0·55 |
| Q33 | 3 | Silicon NPN transistors 2N1711 | 0·55 |
| Q34 | 7 | Silicon NPN transistors 2N2369, 500MHz (code P397) | 0·55 |
| Q35 | 3 | Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905 | 0·55 |
| Q36 | 7 | 2N3646 TO-18 plastic 300 MHz NPN | 0·55 |
| Q37 | 3 | 2N3053 NPN Silicon transistors | 0·55 |
| Q38 | 7 | NPN transistors 4 × 2N3703, 3 × 2N3702 | 0·55 |

**ELECTRONIC SLIDE-RULE**
The MK Slide Rule, designed to simplify Electronic calculations features the following scales:— Conversion of Frequency and Wavelength. Calculation of L. C and fo of Tuned Circuits. Reactance and Self-Inductance. Area of Circles. Volume of Cylinders. Resistance of Conductors. Weight of Conductors. Decibel Calculations. Angle Functions. Natural Logs and 'e' Functions. Multiplication and Division. Squaring, Cubing and Square Roots. Conversion of kW and Hp. A must for every electronic engineer and enthusiast. Size: 22 cm. × 4 cm. Complete with case and instructions. Price each: £3·69

## NEW LOW PRICE TESTED S.C.R.'s

| PIV | 1A TO5 | 3A TO66 | 5A TO66 | 5A TO64 | 7A TO48 | 10A TO48 | 16A TO48 | 03A TO48 |
|---|---|---|---|---|---|---|---|---|
| 50 | 0·26 | 0·28 | 0·39 | 0·39 | 0·52 | 0·55 | 0·59 | 1·27 |
| 100 | 0·28 | 0·37 | 0·52 | 0·52 | 0·55 | 0·64 | 0·70 | 1·54 |
| 200 | 0·39 | 0·41 | 0·54 | 0·54 | 0·63 | 0·67 | 0·83 | 1·76 |
| 400 | 0·48 | 0·52 | 0·62 | 0·62 | 0·74 | 0·83 | 1·03 | 1·93 |
| 600 | 0·59 | 0·63 | 0·75 | 0·75 | 0·85 | 1·07 | 1·38 | — |
| 800 | 0·70 | 0·77 | 0·88 | 0·88 | 0·99 | 1·32 | 1·65 | 4·40 |

## SIL. RECTS. TESTED

| PIV | 300mA | 750mA | 1K | 1·5A | 3A | 10A | 30A |
|---|---|---|---|---|---|---|---|
| 50 | 0·04 | 0·06 | 0·06 | 0·08 | 0·16 | 0·23 | 0·66 |
| 100 | 0·04 | 0·07 | 0·06 | 0·15 | 0·18 | 0·26 | 0·83 |
| 200 | 0·06 | 0·10 | 0·07 | 0·16 | 0·22 | 0·27 | 1·10 |
| 400 | 0·07 | 0·15 | 0·08 | 0·22 | 0·30 | 0·41 | 1·38 |
| 600 | 0·08 | 0·18 | 0·11 | 0·26 | 0·38 | 0·50 | 2·05 |
| 800 | 0·11 | 0·19 | 0·12 | 0·28 | 0·41 | 0·61 | 2·20 |
| 1000 | 0·12 | 0·28 | 0·16 | 0·33 | 0·51 | 0·70 | 2·75 |
| 1200 | — | 0·37 | — | 0·42 | 0·63 | 0·83 | — |

## POWER TRANS BONANZA!

**GENERAL PURPOSE GERM. PNP**
Coded GP100. BRAND NEW TO-3 CASE. POSSIBLE REPLACE:—OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. TI3027-3028, 2N250A 2N456A-457A-458A, 2N511 A & B. 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

| PRICE | 1-24 | 25-99 | 100 up |
|---|---|---|---|
| | 48p each | 44p each | 40p each |

**SILICON High Voltage 250V NPN**
TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
OUR PRICE EACH:

| 1-24 | 25-99 | 100 up |
|---|---|---|
| 55p | 50p | 44p |

## 2N3055

115 WATT SII POWER NPN 55p EACH.

**SILICON 50 WATTS MATCHED NPN/PNP**
BIP 19 NPN TO-3 Plastic. BIP 20 PNP. Brand new. VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.
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| T5 | 8 | 2G382T | OC82 |
| T6 | 8 | 2G344B | OC44 |
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|---|---|---|---|---|---|---|---|---|---|---|---|
| SN7400 | 0·17 | 0·16 | 0·13 | SN7450 | 0·17 | 0·16 | 0·13 | SN74141 | 0·74 | 0·71 | 0·64 |
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| SN7405 | 0·17 | 0·16 | 0·13 | SN7470 | 0·32 | 0·29 | 0·27 | SN74154 | £1·98 | £1·87 | £1·76 |
| SN7406 | 0·39 | 0·34 | 0·31 | SN7472 | 0·32 | 0·29 | 0·27 | SN74155 | £1·54 | £1·43 | £1·32 |
| SN7407 | 0·39 | 0·34 | 0·31 | SN7473 | 0·41 | 0·39 | 0·35 | SN74156 | £1·54 | £1·43 | £1·32 |
| SN7408 | 0·20 | 0·19 | 0·18 | SN7474 | 0·41 | 0·39 | 0·35 | SN74157 | £2·09 | £1·98 | £1·87 |
| SN7409 | 0·20 | 0·19 | 0·18 | SN7475 | 0·50 | 0·48 | 0·46 | SN74160 | £1·98 | £1·87 | £1·76 |
| SN7410 | 0·17 | 0·16 | 0·18 | SN7476 | 0·44 | 0·43 | 0·42 | SN74161 | £1·98 | £1·87 | £1·76 |
| SN7411 | 0·28 | 0·27 | 0·26 | SN7480 | 0·74 | 0·71 | 0·64 | SN74162 | £4·40 | £4·13 | £3·85 |
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| SN7422 | 0·55 | 0·53 | 0·50 | SN7486 | 0·35 | 0·34 | 0·33 | SN74175 | £1·76 | £1·65 | £1·54 |
| SN7423 | 0·55 | 0·53 | 0·50 | SN7489 | £6·05 | £5·78 | £5·50 | SN74176 | £2·75 | £2·64 | £2·53 |
| SN7425 | 0·55 | 0·53 | 0·50 | SN7490 | 0·74 | 0·71 | 0·64 | SN74177 | £2·75 | £2·64 | £2·53 |
| SN7426 | 0·50 | 0·46 | 0·44 | SN7491 | £1·10 | £1·05 | 0·99 | SN74180 | £2·20 | £1·76 | £1·54 |
| SN7427 | 0·50 | 0·46 | 0·44 | SN7492 | 0·74 | 0·71 | 0·64 | SN74181 | £6·05 | £5·50 | £5·23 |
| SN7428 | 0·77 | 0·72 | 0·66 | SN7493 | 0·74 | 0·64 | 0·64 | SN74182 | £2·20 | £1·98 | £1·76 |
| SN7430 | 0·17 | 0·16 | 0·13 | SN7494 | 0·85 | 0·82 | 0·75 | SN74184 | £3·85 | £3·58 | £3·30 |
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| SN7433 | 0·88 | 0·83 | 0·77 | SM7496 | 0·96 | 0·93 | 0·86 | SN74191 | £2·09 | £2·04 | £1·98 |
| SN7437 | 0·71 | 0·68 | 0·66 | SN74100 | £1·82 | £1·76 | £1·71 | SN74192 | £2·15 | £2·09 | £2·04 |
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3 Terminal Pos Volt Reg. TO.3 Plastic O/P 1.5 Amps. uA7805 5V. & uA7812 12V. £1·76 each.

## The AL50 HI-FI AUDIO AMPL 50W pk 25w (RMS)

0·1% DISTORTION! HI-FI AUDIO AMPLIFIER

- Frequency Response 15Hz to 100,000—1dB.
- Load—3, 4, 8 or 16 ohms. ● Supply voltage 10-35 Volts.
- Distortion—better than 0·1% at 1kHz.
- Signal to noise ratio 80dB.
- Overall size 63 mm × 105 mm × 13 mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.


**BRITISH MADE. only £3·58 each**

## STABILISED POWER

### MODULE SPM80 £3·25

AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

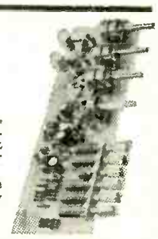
**TRANSFORMER BMT80 £2·15 p. & p. 25p**

## NUMERICAL INDICATOR TUBES

| MODEL | CD66 | GR116 | 3015F Minitron |
|---|---|---|---|
| Anode voltage (Vdc) | 170min | 175min | 5 |
| Cathode Current (mA) | 2·3 | 14 | 8 |
| Numerical Height (mm) | 16 | 13 | 9 |
| Tube Height (mm) | 47 | 32 | 22 |
| Tube Diameter (mm) | 19 | 13 | 12 wide |
| I.C. Driver Rec. | BP41/14 141 | BP41 or 141 | BP47 |
| PRICE EACH | £1·87 | £1·70 | £1·50 |

All indicators 0·9 + Decimal point. All side viewing. Full data for all types available on request.

## STEREO PRE-AMPLIFIER TYPE PA100



Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

### SPECIFICATION:

| | | | |
|---|---|---|---|
| Frequency response | 20Hz—20kHz ±1dB | Bass control | ±15dB at 20Hz |
| Harmonic distortion | better than 0·1% | Treble control | ±15dB at 20kHz |
| Inputs: 1. Tape head | 1·25mV into 50KΩ | Filters: Rumble (high pass) | 100 Hz |
| 2. Radio, Tuner | 35mV into 50KΩ | Scratch (low pass) | 8kHz |
| 3. Magnetic P.U. | 1·5mV into 50KΩ | Signal/noise ratio | better than +65dB |
| All input voltages are for an output of 250mV. | | Input overload | +26dB |
| Tape and P.U. inputs equalised to RIAA curve | | Supply | +35 volts at 20mA |
| within ±1dB from 20Hz to 20kHz. | | Dimensions | 292×82×35 mm |

**SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25.30 FREE p.&p**

**only £13·15**

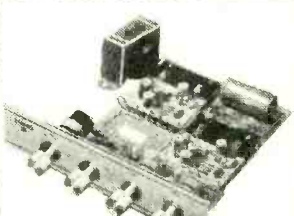
## INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications. but are ideal for learning about I.C's and experimental work.

| Pak No. Contents | Price | Pak No. Contents | Price | Pak No. Contents | Price |
|---|---|---|---|---|---|
| UIC00=12±7400 | 0·55 | UIC46=5×7446 | 0·55 | UIC90=5×7490 | 0·55 |
| UIC01=12×7401 | 0·55 | UIC48=5×7448 | 0·55 | UIC91=5×7491 | 0·55 |
| UIC02=12×7402 | 0·55 | UIC50=12×7450 | 0·55 | UIC92=5×7492 | 0·55 |
| UIC03=12×7403 | 0·55 | UI351=12×7451 | 0·55 | UIC93=5×7493 | 0·55 |
| UIC04=12×7404 | 0·55 | UIC53=12×7453 | 0·55 | UIC94=5×7494 | 0·55 |
| UIC05=12×7405 | 0·55 | UIC54=12×7454 | 0·55 | UIC95=5×7495 | 0·55 |
| UIC06=8×7406 | 0·55 | UIC60=12×7460 | 0·55 | UIC96=5×7496 | 0·55 |
| UIC07=8×7407 | 0·55 | UIC70=8×7470 | 0·55 | UIC100=5×74100 | 0·55 |
| UIC10=12×7410 | 0·55 | UIC72=8×7472 | 0·55 | UIC121=5×74121 | 0·55 |
| UIC20=12×7420 | 0·55 | UIC73=8×7473 | 0·55 | UIC141=5×74141 | 0·55 |
| UIC30=12×7430 | 0·55 | UIC74=8×7474 | 0·55 | UIC151=5×74151 | 0·55 |
| UIC40=12×7440 | 0·55 | UIC76=8×7476 | 0·55 | UIC154=5×74154 | 0·55 |
| UIC41=5×7441 | 0·55 | UIC80=5×7480 | 0·55 | UIC193=5×74193 | 0·55 |
| UIC42=5×7442 | 0·55 | UIC81=5×7481 | 0·55 | UIC199=5×74199 | 0·55 |
| UIC43=5×7443 | 0·55 | UIC82=5×7482 | 0·55 | | |
| UIC44=5×7444 | 0·55 | UIC83=5×7483 | 0·55 | | |
| UIC45=5×7445 | 0·55 | UIC86=5×7486 | 0·55 | UICXI=25 Assorted 74's | 1·55 |

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

## The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm This compact unit comes complete with on/off switch, volume control, balance, bass and treble controls. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet.

| | |
|---|---|
| Output power 20w peak | Input 1 (Cer.) 300mV into 1M |
| Freq. res. 25Hz-25kHz | Input 2 (Aux.) 4mV into 30K |
| Harmonic distortion typically 0·25% at 1 watt | Bass control ±12dB at 60Hz |
| | Treble con. ±14dB at 14kHz |

**£13·47 free p. & p.**

## NEW COMPONENT PAK BARGAINS

| Pack No. | Qty. | Description | Price |
|---|---|---|---|
| C 1 | 250 | Resistors mixed values approx. count by weight | 0·55 |
| C 2 | 200 | Capacitors mixed values approx. count by weight | 0·55 |
| C 3 | 50 | Precision Resistors 1%, mixed values | 0·55 |
| C 4 | 75 | ⅛th W Resistors mixed preferred values | 0·55 |
| C 5 | 5 | Pieces assorted Ferrite Rods | 0·55 |
| C 6 | 2 | Tuning Gangs, MW/LW/VHF | 0·55 |
| C 7 | 1 | Pack Wire 50 metres assorted colours | 0·55 |
| C 8 | 10 | Reed Switches | 0·55 |
| C 9 | 3 | Micro Switches | 0·55 |
| C10 | 15 | Assorted Pots & Pre-Sets | 0·55 |
| C11 | 5 | Jack Sockets 3 × 3·5mm 2 × Standard Switch Types | 0·55 |
| C12 | 40 | Paper Condensers preferred types mixed values | 0·55 |
| C13 | 20 | Electrolytics Trans. types | 0·55 |
| C14 | 1 | Pack assorted Hardware—Nuts/Bolts, Grommets etc. | 0·55 |
| C15 | 4 | Mains Toggle Switches, 2 Amp D/P | 0·55 |
| C16 | 20 | Assorted Tag Strips & Panels | 0·55 |
| C17 | 10 | Assorted Control Knobs | 0·55 |
| C18 | 4 | Rotary Wave Change Switches | 0·55 |
| C19 | 3 | Relays 6—24V Operating | 0·55 |
| C20 | 4 | Sheets Copper Laminate approx. 10″ × 7″ | 0·55 |

Please add 10p post and packing on all component packs, plus a further 10p on pack Nos. C1, C2, C19, C20.

### RTL MICROLOGIC CIRCUITS

| | Price each 1–24 | 25–99 | 100 up |
|---|---|---|---|
| Epoxy TO-5 case uL900 Buffer | 38p | 36p | 29p |
| uL914 Dual 2I/p gate | 38p | 36p | 26p |
| uL923 J-K flip-flop | 55p | 51p | 49p |

Data and Circuits Booklet for IC's Price 8p.

### DUAL-IN-LINE IC's. TWO Ranges PROFESSIONAL & NEW LOW COST.

| PROF. TYPE No. | 1–24 | 25–99 | 100 up. |
|---|---|---|---|
| TSO 14 pin type | 33p | 30p | 28p |
| TSO 16 „ „ | 39p | 35p | 33p |
| LOW COST No. | | | |
| BPS 14 | 17p | 15p | 12p |
| BPS 16 | 18p | 16p | 13p |

### LINEAR I.C.'s—FULL SPEC.

| Type No. | Price 1–24 | 25–99 | 100 up |
|---|---|---|---|
| BP 201C—SL201C | 70p | 59p | 50p |
| BP 701C—SL701C | 70p | 55p | 50p |
| BP 702C—SL702C | 70p | 55p | 50p |
| BP 702—72702 | 59p | 50p | 44p |
| BP 709—72709 | 40p | 38p | 33p |
| BP 709P—µA709C | 40p | 38p | 33p |
| BP 710—72710 | 49p | 46p | 44p |
| BP 711—µA711 | 50p | 48p | 44p |
| BP 741—72741 | 55p | 50p | 45p |
| µA703C | 31p | 29p | 27p |
| TAA 263— | 77p | 66p | 61p |
| TAA 293— | 99p | 83p | 77p |
| TAA 350 | £1·87p | £1·74p | £1·65p |

S.G.S. EA1000 £2·90

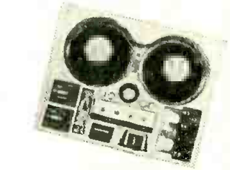
### ROCK BOTTOM PRICES LOGIC DTL 930 Series I.C's

| Type No. | Price 1–24 | 25–99 | 100 up |
|---|---|---|---|
| BP930 | 13p | 12p | 11p |
| BP932 | 14p | 13p | 12p |
| BP933 | 14p | 13p | 12p |
| BP935 | 14p | 13p | 12p |
| BP936 | 14p | 13p | 12p |
| BP944 | 14p | 13p | 12p |
| BP945 | 28p | 27p | 24p |
| BP946 | 13p | 12p | 11p |
| BP948 | 28p | 27p | 24p |
| BP951 | 72p | 66p | 61p |
| BP962 | 13p | 12p | 11p |
| BP9093 | 44p | 42p | 39p |
| BP9094 | 44p | 42p | 39p |
| BP9097 | 44p | 42p | 39p |
| BP9099 | 44p | 42p | 39p |

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

## SYSTEM 12 STEREO

Each Kit contains two Amplifier Modules, 3 watts RMS, two loudspeakers, 15 ohms, the pre-amplifier, transformer, power supply module, front panel and other accessories, as well as an illustrated stage-by-stage instruction booklet designed for the beginner. Further details available on request.



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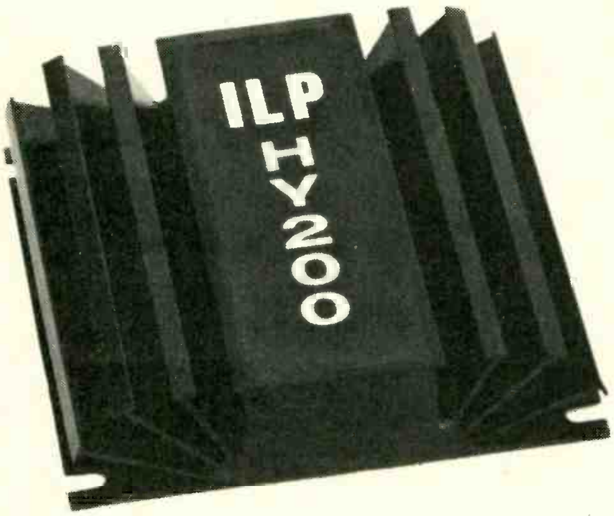
*Postage and packing add 10p. Overseas add extra for airmail. Minimum order 50p. Cash with order please.*

*Guaranteed Satisfaction or Money Back*

# I.L.P. (Electronics) Ltd

# 100 WATTS!




- ★ NO EXTERNAL COMPONENTS
- ★ MECHANICALLY & ELECTRICALLY ROBUST
- ★ INTEGRAL HEATSINK
- ★ HERMETICALLY SEALED UNIT
- ★ ATTRACTIVE APPEARANCE
- ★ LOW COST
- ★ BRITISH BUILT

With the development of the HY200, ILP bring you the first COMPLETE Hybrid Power Amplifier.
COMPLETE: because the HY200 uses no external components!
COMPLETE: because the HY200 is its own heatsink!

By the use of integrated circuit technique, using 27 transistors, the HY200 achieves total component integration. The use of specially developed high thermally conductive alloy and encapsulant is responsible for its compact size and robust nature.

The module is protected by the generous design of the output circuit, incorporating 25amp transistors. A fuse in the speaker line completes protection.

Only 5 connections are provided, input, output, power lines and earth.

**Output Power:** 100 watts RMS; 200 watts peak music power
**Input Impedance:** 10KΩ
**Input Sensitivity:** 0Dbm (0.775volt RMS)
**Load Impedance:** 4-16Ω
**Total Harmonic Distortion:** less than 0.1% at 100 watts typically 0.05%
**Signal: Noise:** Better than 75Db relative to 100 watts
**Frequency response:** 10Hz-50KHz ±1Db
**Supply Voltage:** ±45volts
**APPLICATIONS:** P.A., Disco, Groups, Hi-Fi, Industrial.

**PRICE: £14.90 inc. VAT & P & P**

Trade applications welcomed

**DELIVERY FROM JULY 1st**

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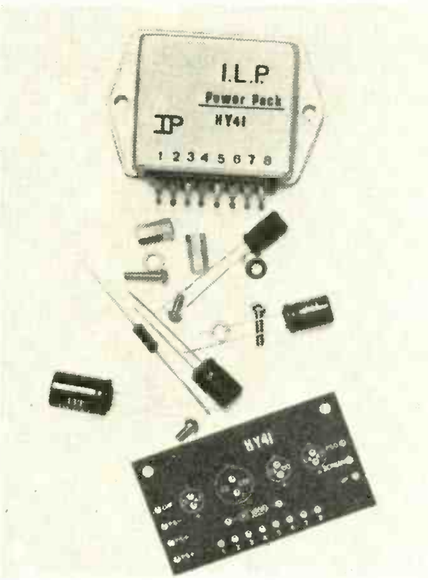



## THE HY41

The HY41 supersedes the popular HY40 introduced by ILP last year. This highly improved module achieves true High Fidelity with a dramatic reduction in distortion (typically 0.05% at 1KHz into 8 ohms!) and is electronically and mechanically compatible with the HY40.

With this important improvement the HY41 retains all of the quality characteristics found in the earlier version and P.C. board, Resistor, Capacitors, Hardware Mountings and comprehensive manual are included in the basic kit. No further components are required to construct a complete power amplifier of extremely high performance sufficiently versatile to provide power not merely for Hi-Fi but also for public address systems and industry.

The free manual gives a full circuit diagram of the HY41 and its various applications including a complete stereo amplifier.

Like its predecessor the HY41 is based on conventional and proven circuit techniques developed over recent years.

**OUTPUT POWER:** British Rating 40 WATTS PEAK, 20 watts R.M.S. continuous.
**LOAD IMPEDANCE:** 4–16 ohms.
**INPUT IMPEDANCE:** 30K ohms at 1KHz.
**VOLTAGE GAIN:** 30db at 1KHz

**TOTAL HARMONIC DISTORTION:** less than 0.15% (typical 0.05%) at 1KHz.
**FREQUENCY RESPONSE:** 5Hz–50KHz ± 1db.
**SUPPLY VOLTAGE:** ± 22.5volts D.C.
**SUPPLY CURRENT:** 0.8 amps maximum.

PRICE: inc. comprehensive manual, P.C. board, five extra components and P. & P.:—
**MONO: £5.39** **STEREO: £10.78** This is inclusive of V.A.T. plus P. & P.

## UNIQUE HYBRID PRE-AMPLIFIER

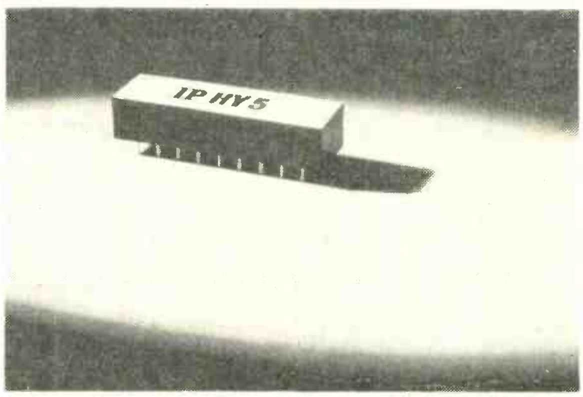
The HY5 has rapidly established a position in the WORLD as the sole hybrid pre-amplifier to contain all feedback and equalization networks within an integrated pre-amplifier circuit.

Supplied with the HY5 are two stabilizing capacitors and by the addition of volume, treble and bass potentiometers it is ready for use.

Internally the HY5 provides equalization for almost every conceivable input, the desired function is achieved by use of a multi-way switch or by direct interconnection,

Two distinctive features of the HY5 are its inbuilt stabilization circuit, allowing it to be run off any unregulated power supply from 16–25 Volts and a balance circuit which, when linked by a balance control to a second HY5, forms a complete stereo pre-amplifier.

Specifically and critically designed to meet exacting Hi-Fi standards, the HY5 combines extremely low noise with a high overload capability. When used in conjunction with the HY41 and PSU45 forms a completely intergrated system.

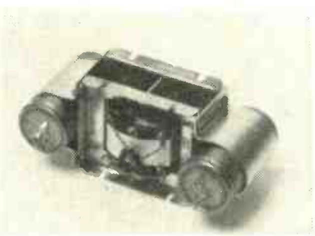



**INPUTS**
Magnetic Pick-up (within ±1db RIAA curve) 2mV. 47K Ω
Tape Replay (external components to suit head). 4mV. 47KΩ
Microphone (flat) 10mV. 47K Ω
Ceramic Pick-up (equalized and compensatable) 20–2000mV. variable.
Tuner (flat) 250mV. 100K Ω
Auxiliary 1 250mV. 47K Ω
Auxiliary 2 2–20mV. 100K Ω

**ACTIVE TONE CONTROLS (Baxendall)**
Treble ± 12db.
Bass ± 12db.
**INTERNAL STABILIZATION**
Enables the HY5 to share an unregulated supply with the Power Amplifier.
**SUPPLY VOLTAGE**
16–25 volts

**SUPPLY CURRENT**
6mA approx.
**OVERLOAD CAPABILITY**
better than 26db on most sensitive input infinite on tuner and auxl.
**OUTPUT NOISE VOLTAGE:** 0.5mV.

PRICE: **MONO: £3.96** **STEREO: £7.92** This is inclusive of V.A.T. plus P. & P.



## POWER SUPPLY PSU45

The versatile P.S.U.45 is designed to supply your HY41's +HY5's in stereo or mono format.

**Specification**

Input: 200–240 Volts.
Output: ± 22.5 Volts at 2 amps.
Overall Dimensions: L. 7"; D. 3.8"; H. 3.1"
PRICE: **£4.95** This is inclusive of V.A.T. plus P. & P.

Please note we reserve the right to substitute at our discretion updated versions of advertised designs where applicable

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WW—107 FOR FURTHER DETAILS

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| 6V | 10,000 | 2,200 | 18·0 × 31·5 | **9·0p** |
| | 11,700 | 3,300 | 18·0 × 40·0 | **11·0p** |
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| 10V | 20,000 | 33 | 6·3 × 16·0 | **2·5p** |
| | 2,500 | 47 | 8·0 × 16·0 | **2·5p** |
| | 8,000 | 330 | 10·0 × 31·5 | **2·6p** |
| 10V | 1,500 | 470 | 12·5 × 31·5 | **4·5p** |
| | 41,000 | 1,000 | 12·5 × 31·5 | **5·5p** |
| | 21,000 | 2,200 | 18·0 × 40·0 | **10·0p** |
| | 20,460 | 3,300 | 22·4 × 40·0 | **13·0p** |
| 16V | 18,000 | 220 | 10·0 × 31·5 | **3·3p** |
| | 27,500 | 330 | 12·5 × 31·5 | **5·0p** |
| | 23,760 | 470 | 12·5 × 31·5 | **5·6p** |
| | 1,500 | 2,200 | 22·4 × 40·0 | **14·0p** |

| Voltage | Quantity | Capacitance µF | Dimensions D × L (mm) | Price |
|---|---|---|---|---|
| 25V | 25,000 | 100 | 10·0 × 25·0 | **3·0p** |
| | 12,500 | 220 | 12·5 × 31·5 | **5·0p** |
| | 50,000 | 330 | 12·5 × 31·5 | **5·6p** |
| | 35,200 | 470 | 18·0 × 31·5 | **6·0p** |
| | 23,650 | 1,000 | 18·0 × 40·0 | **10·0p** |
| 35V | 37,500 | 100 | 12·5 × 31·5 | **3·3p** |
| | 15,000 | 220 | 12·5 × 31·5 | **6·0p** |
| | 5,800 | 330 | 18·0 × 31·5 | **9·0p** |
| | 15,000 | 470 | 18·0 × 40·0 | **9·3p** |
| | 15,000 | 1,000 | 22·4 × 40·0 | **12·0p** |
| 50V | 2,000 | 3·3 | 6·3 × 16·0 | **3·0p** |
| | 6,200 | 220 | 18·0 × 40·0 | **8·8p** |

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| 5K2 | 4,000 | 5K6 | 31,500 | 8K2 | 59,150 |
| 15K | 5,150 | 18K | 3,950 | 22K | 6,000 |
| 47K | 24,200 | 100K | 2,000 | 120K | 2,000 |
| 150K | 13,300 | 330K | 2,850 | 470K | 23,400 |
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| 8M2 | 250 | 10M | 32,450 | 10AD | |

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1215872 TYPE 1301.......7 TRACK
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### MAINS ISOLATING SERIES

**Primary 200-250 Volts Secondary 240 Volts Centre Tapped (120V) and Earth Shielded**
**ALSO AVAILABLE WITH 115/120V SECONDARY WINDING**

| Ref. No. | VA (Watts) | Weight lb | oz | Size cm. | £ | P & P p |
|---|---|---|---|---|---|---|
| 07 | 20 | 1 | 11 | 7·0 × 6·0 × 6·5 | 1·77 | 30 |
| 100 | 60 | 3 | 8 | 8·9 × 8·0 × 7·7 | 2 62 | 36 |
| 61 | 100 | 5 | 12 | 10·2 × 8·9 × 8·3 | 2·88 | 52 |
| 30 | 200 | 9 | 8 | 12·0 × 10·3 × 10·0 | 4·83 | 52 |
| 62 | 250 | 12 | 4 | 9·5 × 12·7 × 11·4 | 6·38 | 67 |
| 55 | 350 | 15 | 0 | 14·0 × 10·8 × 12·4 | 8·55 | 82 |
| 63 | 500 | 27 | 0 | 17·1 × 11·4 × 15·9 | 12·32 | * |
| 92 | 1000 | 40 | 0 | 17·8 × 17·1 × 21·6 | 22 70 | * |
| 128 | 2000 | 63 | 0 | 24·1 × 21·6 × 15·2 | 37·50 | * |
| 129 | 3000 | 84 | 0 | 21·6 × 21·6 × 20·3 | 58·67 | * |
| 190 | 6000 | 178 | 0 | 31·1 × 35·6 × 17·1 | 96·27 | * |

PLEASE NOTE NEW ADDRESS AS BELOW

**440V 300VA ISOLATOR, Primary 440V Secondary 240V, Centre Tapped Screened and Shrouded, £10·37. P & P 67p.**

### AUTO SERIES (NOT ISOLATED)

| Ref. No. | VA (Watts) | Weight lb | oz | Size cm. | Auto Taps | £ | P & P p |
|---|---|---|---|---|---|---|---|
| 113 | 20 | | 11 | 7·3 × 4·3 × 4·4 | 0-115-210-240 | 0·93 | 22 |
| 64 | 75 | 1 | 14 | 7·0 × 6·4 × 6·0 | 0-115-210-240 | 1·82 | 30 |
| 4 | 150 | 3 | 0 | 8·9 × 6·4 × 7·6 | 0-115-200-220-240 | 2·20 | 36 |
| 66 | 300 | 6 | 0 | 10·2 × 10·2 × 9·5 | | 4·28 | 52 |
| 67 | 500 | 12 | 8 | 14·0 × 10·2 × 11·4 | " " | 6·35 | 67 |
| 84 | 1000 | 16 | 0 | 11·4 × 14·0 × 14·0 | " " | 11·54 | 82 |
| 93 | 1500 | 28 | 9 | 13·5 × 14·9 × 16·5 | " " | 16·72 | * |
| 95 | 2000 | 40 | 0 | 17·8 × 16·5 × 21·6 | " " | 21·82 | * |
| 73 | 3000 | 45 | 8 | 17·4 × 18·1 × 21·3 | " " | 29·70 | * |

### TOTALLY ENCLOSED 115V AUTO TRANSFORMERS

115V 500 Watt totally enclosed auto transformer, complete with mains lead and two 115V outlet sockets. £8·63. P & P 67p
Also available a 20 Watt version. £1·84. P & P 22p.

### LOW VOLTAGE SERIES (ISOLATED)
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| Ref. No. | Amps. 12V | 24V | Weight lb | oz | Size cm. | Secondary Windings | £ | P & P p |
|---|---|---|---|---|---|---|---|---|
| 111 | 0·5 | 0·25 | | 12 | 7·6 × 5·7 × 4·4 | 0-12V at 0·25A × 2 | 0·93 | 22 |
| 213 | 1·0 | 0·5 | 1 | 0 | 8·3 × 5·1 × 5·1 | 0-12V at 0·5A × 2 | 1·11 | 22 |
| 71 | 2 | 1 | 1 | 0 | 7·0 × 6·4 × 5·7 | 0-12V at 1A × 2 | 1·46 | 22 |
| 18 | 4 | 2 | 2 | 4 | 8·3 × 7·0 × 7·0 | 0-12V at 2A × 2 | 2·04 | 36 |
| 70 | 6 | 3 | 3 | 12 | 10·2 × 7·6 × 8·6 | 0-12V at 3A × 2 | 2·46 | 42 |
| 108 | 8 | 4 | 5 | 4 | 10·0 × 8·3 × 8·2 | 0-12V at 4A × 2 | 2·73 | 52 |
| 72 | 10 | 5 | 6 | 3 | 7·9 × 10·8 × 10·2 | 0-12V at 5A × 2 | 3·23 | 52 |
| 17 | 16 | 8 | 7 | 8 | 12·1 × 9·5 × 10·2 | 0-12V at 8A × 2 | 4·99 | 52 |
| 115 | 20 | 10 | 11 | 13 | 12·1 × 11·4 × 10·2 | 0-12V at 10A × 2 | 6·35 | 67 |
| 187 | 30 | 15 | 16 | 12 | 13·3 × 12·1 × 12·1 | 0-12V at 15A × 2 | 11·73 | 82 |
| 226 | 60 | 30 | 34 | 0 | 17·0 × 14·5 × 12·5 | 0-12V at 30A × 2 | 21·57 | * |

### 30 VOLT RANGE

| Ref. No. | Amps. | Weight lb | oz. | Size cm. | Secondary Taps | £ | P & P p |
|---|---|---|---|---|---|---|---|
| 112 | 0·5 | 1 | 4 | 8·3 × 3·7 × 4·9 | 0-12-15-20-24-30V | 1·11 | 22 |
| 79 | 1·0 | 2 | 0 | 7·0 × 6·4 × 6·0 | " " | 1·48 | 36 |
| 3 | 2·0 | 3 | 2 | 8·9 × 7·0 × 7·6 | " " | 2·21 | 36 |
| 20 | 3·0 | 4 | 6 | 10·2 × 8·9 × 8·6 | " " | 2·72 | 42 |
| 21 | 4·0 | 6 | 0 | 10·2 × 10·0 × 8·6 | " " | 3·23 | 52 |
| 51 | 5·0 | 6 | 8 | 12·1 × 10·0 × 8·6 | " " | 4·02 | 52 |
| 117 | 6·0 | 7 | 8 | 12·1 × 10·0 × 10·2 | " " | 4·80 | 52 |
| 88 | 8·0 | 10 | 0 | 14·0 × 11·7 × 10·0 | " " | 6·20 | 67 |
| 89 | 10·0 | 12 | 2 | 14·0 × 10·2 × 11·4 | " " | 7·85 | 67 |

### 50 VOLT RANGE

| Ref. No. | Amps. | Weight lb | oz | Size cm. | Secondary Taps | £ | P & P p |
|---|---|---|---|---|---|---|---|
| 102 | 0·5 | 1 | 11 | 7·0 × 7·0 × 5·7 | 0-19-25-33-40-50V | 1·46 | 30 |
| 103 | 1·0 | 2 | 10 | 8·3 × 7·3 × 7·0 | " " | 2·13 | 36 |
| 104 | 2·0 | 5 | 0 | 10·2 × 8·9 × 8·6 | " " | 2·96 | 42 |
| 105 | 3·0 | 6 | 0 | 10·2 × 10·2 × 8·3 | " " | 4·01 | 52 |
| 106 | 4·0 | 9 | 4 | 12·1 × 11·4 × 10·2 | " " | 5·31 | 52 |
| 107 | 6·0 | 12 | 4 | 12·1 × 11·1 × 13·3 | " " | 7.85 | 67 |
| 118 | 8·0 | 18 | 9 | 13·3 × 13·3 × 12·1 | " " | 10·25 | 97 |
| 119 | 10·0 | 19 | 12 | 16·5 × 11·4 × 15·9 | " " | 12·85 | 97 |

### 60 VOLT RANGE

| Ref. No. | Amps. | Weight lb | oz | Size cm. | Secondary Taps | £ | P & P p |
|---|---|---|---|---|---|---|---|
| 124 | 0·5 | 2 | 4 | 8·3 × 9·5 × 6·7 | 0-24-30-40-48-60V | 1·48 | 36 |
| 126 | 1·0 | 3 | 0 | 8·9 × 7·6 × 7·6 | " " | 2·06 | 36 |
| 127 | 2·0 | 5 | 6 | 10·2 × 8·9 × 8·6 | " " | 3·23 | 42 |
| 125 | 3·0 | 8 | 8 | 11·9 × 9·5 × 10·0 | " " | 4·92 | 52 |
| 123 | 4·0 | 10 | 6 | 11·4 × 9·5 × 11·4 | " " | 6·35 | 67 |
| 120 | 6·0 | 16 | 12 | 13·3 × 12·1 × 12·1 | " " | 9·20 | 82 |
| 122 | 10·0 | 23 | 2 | 16·5 × 12·7 × 16·5 | " " | 15·23 | * |

### EQUIPMENT TRANSFORMER

*REF 238* PRI 0240 SCREEN SEC 3·0 3V RMS at 200mA SIZE CM 2·8 x 2·6 x 2·0 WEIGHT 2oz £1·08 P & P 10p.

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**PRIMARY 200-250 VOLT FOR CHARGING 6 OR 12 VOLT BATTERIES**

| Ref. No. | Amps. | Weight lb | oz | Size cm. | | £ | P & P p |
|---|---|---|---|---|---|---|---|
| 45 | 1·5 | 1 | 9 | 7·0 × 6·0 × 6·0 | Please note, these units do not include rectifier. | 1·47 | 30 |
| 5 | 4·0 | 3 | 11 | 10·2 × 7·0 × 8·3 | | 2·23 | 42 |
| 86 | 6·0 | 5 | 12 | 10·2 × 8·9 × 8·3 | | 3·37 | 52 |
| 146 | 8·0 | 6 | 4 | 8·9 × 10·2 × 10·2 | | 3·84 | 52 |
| 50 | 12·5 | 11 | 14 | 13·3 × 10·8 × 12·1 | | 5·72 | 67 |

All ratings are continuous. Standard construction: open with solder tags and wax impregnation. Enclosed styles to order.

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2N 3055 **68p** each with mica and bushes
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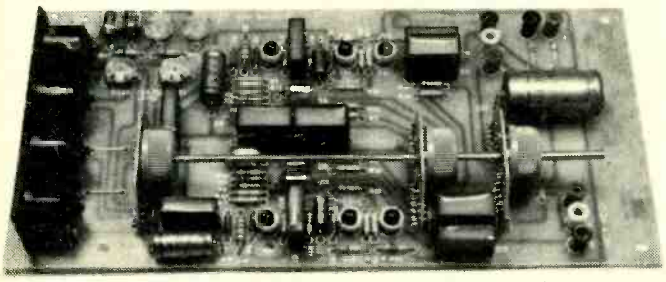
**Audio Kits**



This is our Bailey/Burrows Stereo pre-amp front end. We think it is the best engineered kit of the best pre-amp circuit available, and there is a back end/tone control unit of similar advanced design to go with it which is only $1\frac{1}{2}$" deep so it fits almost anywhere, but of course it's at its best in a Hart universal amplifier metalwork with a couple of Hart Bailey 30 watt power amps to keep it company. That's a recipe for real Hi-Fi with electronics you'll be too proud to cover up.

Also a delight to the connoisseur are our printed circuits and components for the Stuart tape circuits.

This is a most useful high quality circuit with the record, replay and bias functions on separate boards thus giving considerable versatility of use. For instance a stereo replay channel can be built for £6 for single speed use without external components or a switch may be added for multispeed operation.

*Stuart reprints all three articles under one cover.*
*Price 30p. No V.A.T.*

## WE ARE SUPPLYING

Printed Circuit Boards, Components and Kits for the

## D. O'N. WADDINGTON DIGITAL MULTIMETER

This most interesting project fulfils the long-felt want for a Digital Multimeter with the added bonus of counter/timer functions, all at a price which makes it extremely attractive to the amateur, educational or commercial user.

Please send 9" x 4" SAE for full details:

**Penylan Mill, Oswestry, Salop.**

Personal callers are always welcome, but please note we are closed all day Saturday

# ATTENTION!

## PLESSEY RADAR MARK V and MARK VII DISPLAY UNITS

The following brand new P.W. Boards are available at a fraction of their original cost.

OUR SPECIAL PRICE **£15.00 each**

| *Part No.* | *Part No.* | *Part No.* | *Part No.* |
|---|---|---|---|
| 12305/A | 12292/A | 687/1/00925/001 | 12048/A |
| 12346/A | 12458/A | 12065/A | 12047/A |
| 12439/A | 12344/A | 12327/A | 12551/NP/C EXT. Stalk |
| 12459/A | 12034/A | 17126/A | 12378/A |
| 12447/A | 12336/A | 12961/A | 12343/A |
| 12235/A | 12412/A | 12482/A | 12326/A |
| 419-1-00647 | 12345/A | 12970/A | 687/1/01291 |
| 12100/A | 12353/A | 12972/A | 12422/A |
| 12962/A | 12963/A | 12338/A | 12281/A |
| 12436/A | 12098/A | 12339/A | META for MK VII |
| 12184/A | 12341/A | 12487/A | 687/1/00678 |
| 12187/A | 12968/A | 12325/A | 687/1/00070 |

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# C. T. ELECTRONICS 267 ACTON LANE, LONDON W4 5DG 01-994 6275

**MAIL ORDER DEPT./REGISTERED OFFICE/COMPONENT COUNTER**

## TEST EQUIPMENT

| *Manufacturer* | *Type* | *Price* (ex V.A.T.) |
|---|---|---|
| **EMI** 9524H | Photomultiplier | £8 |
| **Teletronix** 551 | Oscilloscope and B+G Plug-in | £300 |
| **Teletronix** 53/54B | Plug-in | £20 |
| **Teletronix** 53/54E | Plug-in | £20 |
| **Croydon Precision Instruments** KB1 | Kelvin Bridge Ohmeter | £60 |
| **Vibro-Meter Corp.** PBA-1/A | Bridge Supply and Indicator | £120 |
| **Muirhead 21-A** | Varley/Wheatstone/Murray Bridge | £40 |
| **Emouzy** | Electronic Multimeter | £15 |
| **E.I.L.** 22B | Micouac Electronic Testmeter | £18 |
| **Marconi** Mod. 12 | AM/FM Signal Generator 35kHz-18.3MHz | £65 |
| **Cawkell** S.O.I. | Storage Oscilloscope from | £75 |
| **Teletronix** 551 | Oscilloscope and 2 x G Plug-in | £300 |
| **Teletronix** D, G | Plug-in units ea. | £25 |
| **Teletronix** 536 | X-Y Oscilloscope and 2 x B Plug-in | £300 |
| **Teletronix** 661 | Sampling scope and 5TA1 + 4S1 Plug-in | £450 |
| **Eddystone** | Receiver 500-1000MHz | £275 |
| **Marconi** TF 1100 | Sensitive Valve Voltmeter | £28 |
| **Marconi** TF428C | Valve Voltohmeter | £18 |
| **Marconi** TF899 | Valve Millivoltmeter | £12 |
| **Marconi** TF887A | Valve Voltohmeter | £12 |
| **Marconi** | H.F. Absorption Wattmeter 52 ohm 1W/70 ohm 25W | £12 |
| **Marconi** TF1374 | Precision Crystal Calibrator | £30 |
| **Pye** | Scalamp Galvo | £20 |
| **Advance** MG5-40 | 5V 40A Stabilized Power Pack | £70 |
| **Marconi** TF894 | Audio Tester | £50 |
| **Cossor** R109AD5 | 25W Transmitter | £60 |
| **Teletroni c** 545 | Oscilloscope and G Plug-in | £225 |
| **H.P.** 614A | UHF Sig. Generator 750-2100MHz | £85 |
| **Cohn** | D.C. Voltage Standard 10µV-1000V 6 decade | £525 |
| **Marconi** TF1272 | Transistor Test Set | £24 |
| **Solartron** JM1067 | Precision RMS Millivoltmeter 3mV-300V | £52 |
| **Solartron** LM903 | AC Converter-Voltmeter | £50 |
| **Cossor** R109 AB5 Mk. 3 | Receiver | £50 |
| **Marconi** TF144G | Standard Sig. Gen. 85kHz-25MHz | £35 |
| **Cambridge** | Spot Galvo 430 ohm | £18 |
| **Teletronix** B, G, D, H | Plug-ins ea. | £27 |
| **Advance** PM48 | Stabilised Power Pack 15-30V 3A | £23 |
| **E.M.I.** WM16 | Oscilloscope and 7/6 Diff. Amp. | £140 |
| **Baird & Tatlock** | 0.1% Wheatstone Bridge | £50 |
| **Sullivan** | Standard Mica Capacitor 1mfd. 4 decade | £75 |
| **Cambridge** L358113 | Decade Bridge | £58 |
| **Teletronix** 107 | Square Wave Generator | £18 |
| **Avo** FPSK | Oscilloscope Camera with Polaroid Attachment | £120 |
| **Marconi** TF1041 | Valve Voltmeter | £30 |
| **Sony** PV-120VE | Broadcast Standard Videotape Recorder, 2in. tape; 625 line CCIR, 2 Audio Channels | £650 |
| **Marconi** TF928 | FM Deviation Meter 20-100MHz | £28 |
| **Solartron** CD1220 | Oscilloscope and CX1258 Diff. Plug-in | £150 |
| **Solartron** OS103 | LF Decade Oscillator .01-11kHz 0.009-10V 4 phase and square wave outputs | £85 |
| **Ediswan** R666 | L.F. Oscillator .15Hz-5kHz | £20 |
| **Marconi** TF1165 | Electronic Counter 7 digit 1MHz | £35 |
| **Sanders** L026 | Lab. Magnetic Amplifier | £40 |
| **B.P.L.** LC100-C | Coil Comparator .1µH-100mH | £55 |
| **Roband** V50/50 | Stabilised Power Supply 0-500V 500mA | £50 |
| **A.P.T.** 2445 | Twin Stabilised Power Supply 0-100V 250mA | £38 |
| **Muirhead** D-729 | Phasemeter and P.S.U. | £80 |
| **Farnell** TSV12/2 | Transistor P.S.U. 0-12V 2A Metered | £10 |
| **Airmec** 252 | A.F. Signal Generator 30-300kHz bal./unbal. | £28 |
| **Marconi** TF130 | Vacuum Tube Voltmeter | £30 |
| **Honeywell** IK100 | D.C. Reference Standard | p.o.A. |
| **Jerrold** 900A | UHF/VHF Sweep Freq. Generator | p.o.A. |
| **Advance** D1/D | R.F. Signal Generator | £45 |
| **E.M.I.** | 14in. TV Monitor | p.o.A. |
| **Wayne Kerr** M121 | AF Voltmeter | p.o.A. |
| **E.M.I.** | Magnetic Drum Delay Units (Studio Echo Units) | p.o.A. |

This is just a sample list of Test Equipment available. We have hundreds of other items available. Enquiries welcome. Please telephone 01-994-6275.

## LOW-COST OSCILLOSCOPES

**Cossor** 1035, D.B.
**Cossor** 1049 Mk. 3A. D.B.
**Cossor** 1049 Mk. 4. D.B.
**Solartron** AD557.
**Solartron** CD513.2.
**Solartron** CD523 S.2.
**Solartron** CD643.
**Solartron** CD643.2.
**Solartron** CD711S.2.

**E.M.I.** WM2.
WM3B.
WM7.
WN8.
WM16.
WM18.
WM26.

All prices and details on application phone 01-994-6275. Inspection welcome—call at warehouse.

## STABILISED D.C. POWER PACKS (Brand New)

| | |
|---|---|
| **FARNELL** IR 24/10 24V. 10 Amp. | £40 |
| STE 234 30V. 1A. + 10V. 2A. | £38 |
| **COUTANT** ED 200/12/12 5-30V. 2A. Dual supply | £45 |
| ES 500/26 6-30V. 5A. | £35 |
| HTD 60/150/150 Dual supply | £35 |
| **A.P.T.** SCV 32 FI 150V. ½A. | £20 |

## COMMUNICATIONS EQUIPMENT

**POCKET V.H.F. F.M. RADIOTELEPHONE**
Corror Type CC2/8 Mk. 2.
Fully transistorised transmitter/receiver available in two versions:—
Low band; Freq. range 71.5-104MHz, R.F. Output 500mW.
Complete with ¼ wave whip aerial, combined microphone/loudspeaker and 13.3V. rechargeable nickel-cadmium DEAC battery.
**Price £75** + v.a.t.

**U.H.F. 2 watt FIXED RADIO LINK.** 24V. dc./240V. ac. F.M.
TRANSMITTER/Type CC RTX 4A Mk. 1
R.F. Output 2W at 450-470MHz.
RECEIVER/Type CCRR4A Mk. 1 **Price £80.00 per unit**
Full Technical and operating data available. Prices and details on request.
Mains Power Pack for the above **£12.00 each**

**1 + 1 CARRIER EQUIPMENTS.** Cossor Type CC M2A.
Solid state multiplex installations designed for U.H.F. radio systems enabling 2 speech channels each with out of band signalling, if required or the equivalent in telemetry information, to be transmitted simultaneously over a radio system. **Prices and details on request.**

**V.H.F. RADIOTELEPHONE BASE STATION.** Cossor Type CC 603 Transmitter. Simplex or duplex operation, local or remote control with talk through facilities, using double sideband a.m. modulation.
Low-band 71.5-104MHz. or High-band 156-174MHz. versions available.
RF. Output power 25W. into 50 Ohms.
24V. dc. operation. **Prices and details on request**
OPTIONAL POWER SUPPLY Type CC 101 for type CC603 base station P.O.A.

**SELECTIVE CALL SYSTEM.** Coder Type CC 505/50 (50 way) or CC 505/100 (100 way). The Cossor selective call system may be used with any communication system where a base station is required to call any one or all of a number of sub-stations. Both versions available, all new and in original packing.
**Price: 50 way £65** + v.a.t.
**100 way £80** + v.a.t.

**DECODERS £15** ea.

**DEAC RECHARGEABLE BATTERY CASSETTES 13.4V** (nom.) type B/SA 80351/108. Heavy duty encapsulated DEAC supply.
Size 3¼+2¼+1½in. **Price £5** + v.a.t.

**8-WAY BATTERY CHARGER** Type CC 999. Charges up to 8 of the above battery cassettes. **Price £25** + v.a.t.

**12-WAY BATTERY CHARGER** Type CC 999. Charges up to 12 of 13.4V. DEAC batteries. Metered battery condition check.
**Price £35** + v.a.t.

**MICROPHONES**
S. G. Brown Stick Microphone and Stand. Push-to-talk button. 300Ω. **£5** complete.
S. G. Brown Hand-held with push-to-talk button. **£8** each.

## SPECIAL OFFERS

**BRIDGE RECTIFIER.** 6A. 100V. Motorola MDA952-2 **65p.**

**POWER SUPPLY.** 12V. 6.5A. Stabilised Power Supply. Contains 18.5V. 8.5A. sec· Transformer, 4 x 4000µF 25V. Mullard capacitors, 2 x 2N3055 on 2 Redpoint heatsinks, 12A., 120V. Bridge rectifier, stabilised p.c.b. + circuit diagram. The parts alone are worth the asking price of **£13** each inc. carriage.

Send s.a.e. for free circuit diagram.

## ELECTRONIC COMPONENTS

**BARGAIN COMPONENT PACKS**

*Pack No.*
1 500 Carbon resistors, ¼, ½, 1, 2 watt.
2 100 Electrolytic Condensers.
3 250 Ceramic, Polystyrene, Silver Mica, etc., Condensers.
4 250 Polyester, Polycarbonate, Paper, etc., Condensers.
5 25 Potentiometers, assorted.
6 250 High-stab. 1%, 2%, 5% resistors.
7 50 Assorted Tagstrips.
8 1lb Assorted nuts, bolts, washers, spacers, etc.
9 25 Assorted switches, rotary, lever, micro, toggle, etc.
10 50 Preset Potentiometers.
11 Trial mixed component pack **£1.**
12 Jumbo mixed pack **£5.**

**ALL COMPONENTS NEW AND UNUSED**
**£1** + 25p p.p. per pack, **£5** for 5 packs p/free.

## *NOW OPEN:*

**AUDIO ACCESSORY SHOP**
**17 TURNHAM GREEN TERRACE, W.4.**
HEADPHONES, MICROPHONES, SPEAKERS, etc., etc.

**WAREHOUSE**
**20-24 BEAUMONT ROAD, W.4.**
SURPLUS COMPONENTS, TEST EQUIPMENT, etc., etc.

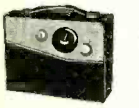

## DRILL CONTROLLER

**New 1kW model.**
Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions **£1·65**, plus 13p post and insurance. Made up model also available **£2·48** plus 13p p. & p

## MIGHTY MIDGET

Probably the finest possible radio, as described in Practical Wireless, January 73. All electronic parts **£2·20** post paid.

## GOOD COMPANION I.C. VERSION



We can now offer these again in I.C. version using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 11in. wide × 8in. high × 3in. deep. Complete assembly instructions, **£6·33** plus 25p post and ins. Excellent tone wood cabinet.

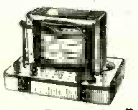
## I CHIP RADIO

Ferranti's latest device ZN414—gives results better than superhet. Supplied complete with technical notes and circuits **£1·38** each. 10 for **£11·11**.

## HI-Q TUNER COMPONENTS

For experimenting with the ZN414

- Kit No. 1 Plessey Miniature Tuning Condenser with built in LW switch and 3in. Ferrit slab and litz wound MW coil **72p**.
- Kit No. 2 Air spaced tuning condenser 6in. ferrit rod litz wound MW and LW coils and wave change switch **94p**.
- Kit No. 3 Air spaced TC with slow motion drive 8in. ferrit rod with litz wound LW and MW coils and wave change switch **£1·10**.
- Kit No. 4 Permeability tuner with fast and slow motion drive and LW loading coils and wave change switch **50p**.

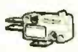


## 12 VOLT 1½ AMP POWER PACK

This comprises double-wound 230/240V mains transformer with full wave rectifier and 2000 mf/d smoothing. Price **£2·20**, plus 20p post & packing.

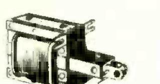
**Heavy Duty Mains Power Pack.** Output voltage adjustable from 15-40V in steps—maximum load 250W—that is from 6 amp at 40V to 15 amp at 15V. This really is a high power heavy duty unit with dozens of workshop uses. Output voltage adjustment is very quick—simply interchange push on leads. Silicon rectifiers and smoothing by 3,000mF. Price **£6·33** plus 65p post.

## MICRO SWITCH



5 amp changeover contacts. **11p** each. 10 for **99p**. 15 amp. S.P Model **15p**, changeover **17p**. each

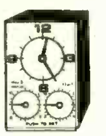
## MAINS OPERATED SOLENOIDS



Model 772—small but powerful 1in. pull—approx. size 1½ × 1½ × 1¾in., **66p**.
Model 4001/—⅜in. pull. Size 2⅞ × 2 × 1¼in. **83p**.
Model TT1—1¾in. pull. Size 3 × 2½ × 2in. **£1·98** plus 20p. post and insurance.

## MAINS TRANSISTOR POWER PACK

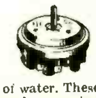
Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries: PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1·10** plus 20p postage.



## TIME SWITCH

Smith's mains driven clock with 15 amp switch, also notes showing how you can wake up with music playing, kettle boiling or come home to a warm house, warn off burglars, keep pets warm, halve your heating bill, etc. **£2·25**.

## PRESSURE SWITCH



Containing a 15 amp. change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machines to turn off water when tub has reached correct level but no doubt has many other applications. **£1·38**.

## EDUCATIONAL KITS—all with pictorial instructions

THIS BALANCE KIT FREE.
Eagle educational kits. Japanese made these are excellent value for money. We do not expect to be able to repeat this offer once stocks are sold. Brief description of each kit is given below and with 3 kits or more we give FREE an accurate 11 piece balance kit. Price of kits **44p** each post paid. Special price for all 7 kits **£3·00** with free balance kit.

**KA2 Lens Kit.** Eleven parts, including candle one concave lens, one convex lens, stage and slit frame, etc. Watch light rays bend as they pass through different lenses.

**KA3 Water Pump Kit.** Thirteen parts. Top of pump is transparent so that operating parts may be observed. Small parts are brightly coloured to be seen easily while working. Three types of pump may be made: Lift pump Force Pump and Force Pump with reservoir and nozzle.

**KA4 Buzzer Kit.** Eleven parts. Transparent covers allow the operation of buzzer to be seen. Illustrates and teaches how electromagnetism with an automatic switch results in an operating buzzer.

**KA7 Electro-Magnet Kit.** Fifteen parts. includes compass. Makes two electro-magnets. one with one layer of wire and one with several layers of wire. Picks up tacks, nails and any small parts showing how magnetism works.

**KA8 Current and Resistance Kit.** Twenty-nine parts, including bench and light bulb. Conduct interesting and educational projects to learn the application of "OHMS LAW" and see the difference in current and resistance with different types and lengths of wire.

**KA9 Bell Kit.** Eight parts, including bell and push button switch. Build a complete electric bell and see how the hammer is triggered to make the bell ring.

**KA10 Morse Key buzzer and bell kit.** 25 part kit, easy to construct, simple to operate.

## THIS MONTH'S SNIP

### SOLENOID OPERATED TAPE DECK

Solenoid operated (so could be remote controlled) tape deck—comprises: motor driven heavy but balanced flywheel which forms capstan. Tape drive is operated by no. 1 solenoid. Two more solenoids operate fast forward and fast reverse. Complete with tape spools record/play back head and erase head. Real bargain at **£6·60**.

## THYRISTOR LIGHT DIMMER

**For any lamp up to 250 watt. Mounted on switch plate to fit in place of standard switch. Virtually no radio interference. Price £3·35. Industrial model 5A £3.30**

## 10 AMP DIMMER CONTROL

For the control of lighting on stage or in a studio or for control of portable equipment in workshops, etc. This has two 13 amp socket outlets each is controlled by a 5 amp solid state regulator. The overall length is 17in., width 3½in. and depth 1½in. In the end is fitted a master On/Off switch indicator, lamp and fuse. Price **£8·25**.

## STANDARD WAFER SWITCHES

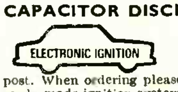
Standard size 1½in. wafer—silver-plated 5 amp. contact, standard ¼in. spindle 2in long—with locking washer and nut.

| No. of Poles | 2 way | 3 way | 4 way | 5 way | 6 way | 8 way | 9 way | 10 way | 12 way |
|---|---|---|---|---|---|---|---|---|---|
| 1 pole | 44p | 44p | 44p | 44p | 44p | 44p | 44p | 44p | 44p |
| 2 poles | 44p | 44p | 44p | 44p | 44p | 44p | 44p | 77p | 77p |
| 3 poles | 44p | 44p | 44p | 44p | 77p | 77p | 77p | £1·04 | £1·04 |
| 4 poles | 44p | 44p | 44p | 77p | 77p | 77p | 77p | £1·32 | £1·32 |
| 5 poles | 44p | 44p | 77p | 77p | £1·04 | £1·04 | £1·04 | £1·60 | £1·60 |
| 6 poles | 44p | 77p | 77p | 77p | £1·04 | £1·04 | £1·04 | £1·87 | £1·87 |
| 7 poles | 77p | 77p | 77p | £1·04 | £1·32 | £1·32 | £1·32 | £2·15 | £2·15 |
| 8 poles | 77p | 77p | 77p | £1·04 | £1·32 | £1·32 | £1·32 | £2·42 | £2·42 |
| 9 poles | 77p | 77p | £1·04 | £1·04 | £1·60 | £1·60 | £1·60 | £2·70 | £2·70 |
| 10 poles | 77p | 77p | £1·04 | £1·32 | £1·60 | £1·60 | £1·60 | £3·00 | £3·00 |
| 11 poles | 77p | £1·04 | £1·04 | £1·32 | £1·87 | £1·87 | £1·87 | £3·25 | £3·25 |
| 12 poles | 77p | £1·04 | £1·04 | £1·32 | £1·87 | £1·87 | £1·87 | £3·52 | £3·52 |

## DISTRIBUTION PANELS

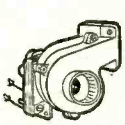
Just what you need for work bench or lab. 4 × 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of heavy cable. Wired up ready to work, **£2·48** plus 25p P. & P.

## CAPACITOR DISCHARGE CAR IGNITION




This system which has proved to be amazingly efficient and reliable was first described in the *Wireless World* about a year ago We can supply kit of parts for an improved and even more efficient version (*Practical Wireless*, June). Price **£5·55** plus 30p post. When ordering please state whether for positive or negative systems. Also available. ready made ignition systems for 6v. vehicles. **£5·78** plus 20p.

## CENTRIFUGAL BLOWER

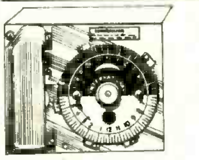


Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4½" × 4½" × 4". When mounted by its flange air is blown into the equipment but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at **£2·05**.

## SPECIAL SUMMER OFFER

### MULLARD UNILEX at Pre V.A.T. price

You want a good stereo system—well here's an offer you should not miss! The four Mullard modules all in original manufacturer's cartons and with original maker's guarantee. **£7** the lot. Control unit with name plate and 4 spun aluminium faced control knobs **£3**. Total **£10** post and V.A.T. paid. 2 Goodmans Speakers **£3**.



## ELECTRIC TIME SWITCH

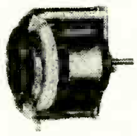
Made by Smiths these are A.C. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5 amp changeover contacts will switch circuit on or off during these periods. **£2·75** post and ins., 23p. Additional time contacts **55p** pair.

## MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.
Model 1153 500mW power output **72p**.
Model 1172 750mW power output **94p**.
Model EP9000 4 watt power output **£1·60**.
EP9001 twin channel or stereo pre amp. **£1·99**.
10% discount if 10 or more ordered.

## WINDSCREEN WIPER CONTROL

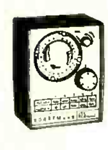
Vary speed of your wiper to suit conditions. All parts and instructions to make. **£2·48**.



## PAPST MOTORS

Est. 1/40th h.p. Made for 110-120 volt working. but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. **£1·65** each. Postage one 23p, two 33p. 230v. model **£3·30**.

## HORSTMANN 24-HOUR TIME SWITCH



With 6 position programmer. When fitted to hot water systems this could programme as follows:—

| Programme | Hot Water | Central Heating |
|---|---|---|
| 0 | Off | Off |
| 1 | Twice Daily | Off |
| 2 | All Day | Off |
| 3 | Twice Daily | Twice Daily |
| 4 | All Day | All Day |
| 5 | Continuously | Continuously |

Suitable of course, to programme other than central heating and hot water, for instance, programme upstairs and downstairs electric heating or heating and cooling or taped music and radio. In fact there is no limit to the versatility of this Programmer. Mains operated. Size 3in. × 3in. × 2in. deep. Price **£3·85** as illustrated but less case.

## TAPE PLAYBACK UNITS

Mains operated. Made by Reditune the famous "music in background people." These are complete units ready to work. They have a superior motor driven flywheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle Two models offered, good as new **£6·50** and somewhat used at **£3·50**. 75p carriage up to 200 miles then 50p per 100 miles extra.
*90 minutes cassettes. Plain* **77p**. *Recorded* **£1**.

## NEW ITEMS THIS MONTH

### LABORATORY INSTRUMENTS

Used but believed in good order—one only of each—on offer to highest bidder. EMI Paroramic wave analyser. 2×Beckman Universal Eput. Timer Model 7360c. Furst Electronics Wow Meter 115RA. Mansons Proportional Oven and Xtal Osc RD140. Airmec Millivolt Meter type 264. Marconi Magnification Meter TF 329G. Airmec Frequency Meter Type 726. Soarton Laboratory Amplifier 15 c/s-350 kc/s Awa 51a. GEC Quartz Xtal Activity Test Set 2-20 mc/s. Muirhead Phasemeter D729 BM. ~~Muirhead Phasemeter D729 B8~~. Heath Kit R-C Bridge C34. ~~RCA~~ Flutter Indicator. Metrix Standard Sig. Generato. 50 mc/s. 50 mc/s to 50 mc.

### METAL CHASSIS

14 gauge sheet steel—size approx. 7in. × 3½in. × 1½in. deep. Cadmium plated punched in the centre to take 3 P.O. 3000 type relays. There is also a removable cover over this section measuring 4½in. long × 3½in. × 2½in. The chassis also has a few holes and could take a small transformer and/or valve holders also some ⅜in. holes for controls, pots etc. This is an ideal chassis for making up a relay unit or similar. These are ex-equipment but in excellent condition and may have a few resistors etc. still attached. Price **40p** each.

### CLOCKWORK TIME SWITCH

For delaying the switching on for up to 12 hours. Being clockwork this is independent of the mains and is therefore useful for remote operation or for battery appliance. The front dial which is calibrated in hours is turned through the required revolution then after pre-set time double pole 15A switch operates. Made by Smiths. Price **£1·65**.

### MAINS TRANSFORMER

Our Ref. MTJ1. Drop through chassis—open construction. 240 v. Primary—9v. 1A. Secondary. Price **77p**. each

### MAINS TRANSFORMER

Our Ref. MTJ2. Parmeko Neptune series. This is a totally enclosed 'C' core construction, upright mounting and black enamelled. For 230/240v. Sec. 25-0-25v. at 50 mA. Idea for mounting on metal chassis mentioned above. Ex-equipment but unused. **77p** each.

### 3 POST OFFICE TYPE 3000 RELAYS

Ex-equipment but guaranteed perfect—any not so would be changed.

1. Ref. REL J1. Has 6 sets of change-over contacts and 2000 ohm coil. **55p** each.
2. Ref. REL J2. 2 pairs that close when relay energized and 2000+1000 ohm coil. Price **44p**.
3. Ref. REL J3. 2 pairs contacts that close and 6.4 K ohm coil. **44p**.

### 1 REV. PER MINUTE MOTOR WITH BEAR-BOX

Made by the famous Chamberlain & Hookham Ltd. These could be made to drive clock or similar. Really robust reliable unit. Price **99p** each.

### 110 REV. PER MINUTE MOTOR WITH GEAR-BOX

Good American make. Operates from mains and will drive switch mechanism or other medium device. Size approx. 4in. × 3in. × 2½in. with 4in. diameter drive shaft. Price **£2·20**.

### 12V. CAR BLOWERS

Units made by Delco. 6 bladed 5in. dia. fan inside heavy duty cylinder. These have really powerful series wound motors giving a terrific air flow suitable for ventilating or heating a car, boat, caravan, etc. Price **£2·20**, plus 40p post and insurance. (Note these are intended for 12V. D.C. but can be run from A.C. up to 30V. The higher the voltage the more the air flow).

### 13 AMP. SWITCHED SOCKETS

By G.E.C. Standard type for fused plugs. Brown bakelite, **17p** each or **£1·50** for 10.

### V.H.E. AMPLIFIERS

With built in mains power pack, these are valve amplifiers, are metal-cased and co-axial inputs and outputs. Optimum amplification at T.V. frequency. Useful also for re-building into another unit which needs a mains power pack. Price **£2·75**.

### 3 CORE MAROON COTTON COVERED FLEX

Very best makers but old coloured code. 6 amp.—23/36 × 100 yd. coil **£2** plus 50p. 15 amp.—70/36 × 50 yd. coil **£3·95** plus 50p post.

### INDICATOR AUDIBLE WARNING

Add this audible warning device to car indicators or dash panel warning lights and your attention will be instantly drawn to the warning lamp kit. £1·20.

### NIGHT LIGHT SWITCH

A simple control to dim a lamp. Kit £1·10.

### GENERAL PURPOSE AMPLIFIER

An audio amplifier of reasonable quality for use with radio tuners—audio oscillators, record decks—electric guitars. etc. Kit £4·90.

### HOME INTERCOM

Keep in touch with this simple, easily connected good quality two way intercom. Kit £4·00.

### FLASHING LIGHT METRONOME

For use in the musical field and the laboratory—where an audible not on click could get lost or become annoying. Kit £1·40.

### MINI ORGAN

A three octave, stylus operated organ—neatly and simply constructed on a printed circuit board. Kit **£4·75**.

### RAIN ALARM II

Sounds an audible alarm as soon as the first rain drops fall. Kit £3·00.

### CASSETTE AMPLIFIER

Boosts the output from cassette tape recorders and transistor radios. Kit £4·50.

### AUDIO SIGNAL MIXER

Where you want to mix speech and music, and to fade them in and out—no tape enthusiast should be without this. Kit **£3·90**.

### AUTO FAN

A thermostatic control for car engine fan, gives quicker warming up time, etc. Kit £2·35.

### SLAVE FLASH

Photos taken with a single flash have a "flat" appearance—a second flash correctly positioned overcomes this. This unit enables a second (or third flash to be automatically triggered. Kit £1·85.

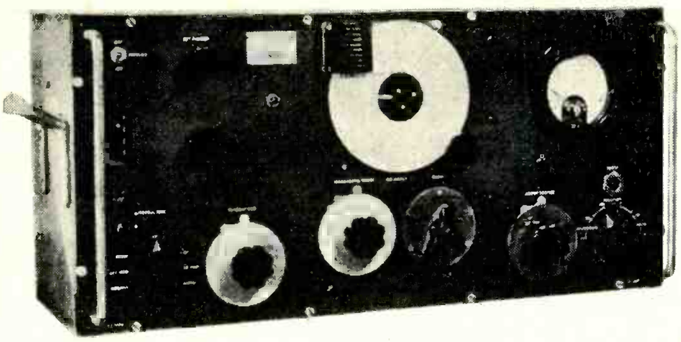
### ELECTRONIC DOORBELL

Not in fact a bell but an electronic circuit that produces an unusual sound when the button is pressed. Kit £4·00.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

# J. BULL (ELECTRICAL) LTD.

**(Dept. W.W.) 7, Park Street, Croydon, CR0 1YD**
**Callers to 102/3, Tamworth Road, Croydon**



**MARCONI SIGNAL GENERATOR TYPE TF-144G:** Freq. 85 Kc/s-25 Mc/s in 8 ranges. Incremental: ±1% at 1 Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV - 1 volt - 52·5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements 29 × 12½ × 10 in. Secondhand condition. **£27·50** each, Carr. £1·50.

**T.1509 TRANSMITTERS (FOR EXPORT ONLY):** General-purpose HF communications transmitter for use in fixed or mobile ground stations. Hand or high-speed keying. Crystal or MO control, with temperature compensated MO circuit.CW, MCW and R/T. Frequency: 1.5 to 20 Mc/s. Modulation: 100% O/put impedance: 50 ohms. Audio input: 600 ohms. Valves: Power Amplifier 2 × 813 and Modulator 2 × 813. Power requirements 200-250 volts a.c., 50 cycles. Power out put 300 watts. Dimensions 2ft. 6in. W. × 2ft. D. × 5ft. H. Weight: 800 lbs. Excellent condition, price **£225.00** each.
**AN/ARC-27 TRANSMITTER/RECEIVER (FOR EXPORT ONLY):** Frequency 225-400 mc. 1750 channels 100 Kc apart with 18 preset channels. Modulation: am. Power output 9 watts. Receiver is superheterodyne. Max. output 2 watts. Antenna: 50 ohm impedance. Power requirements 24v d.c. Complete transmitter with operating cables, control box, headphones, microphone. Price **£250.00** each secondhand, excellent condition.
**POWER SUPPLY suitable for AN/ARC-27:** 100 volts to 250 volts a.c. input. 24v d.c. output @ 41 amps fully smoothed. **£45.00** each.

**FREQUENCY METER BC-221:** 125-20,000 Kc/s, complete with original calibration charts. Checked out, working order. **£18·50** + £1·00 carr. BC-221 Unused as new condition complete with headset, spare valves, charts. **£35·00** + £2·00 carr.

**CT.52 MINIATURE OSCILLOSCOPE:** Portable. Operates from 115V or 250V 50-60c/s; or 180V 500c/s. A small compact tropicalised instrument designed to meet requirements of radar and communication engineers and general electronic service. Measures 9 in. × 8 in. × 6½in. Time base 10c/s-40Kc/s. Y plate sensitivity 40V per cm. Tube 2¾in. Frequency compensated amplifier up to 38dB gain. Bandwidth up to 1 Mc/s. Single sweep facilities. Complete with test leads, metal transit case. As new **£27·50** each. Carr. £1.

**TUNING UNIT:** 24V geared motor driving double 25pf double spaced variable capacitor. One m/c relay and 2 other relays. **£2·50** each 30p post, good condition.
**UHF ASSEMBLY:** (suitable for 1,000MHz conversion) including UHF valves: 2C42, 2C46, 1B40 (complete with associated capacitors and screening), 3 manual counters 0-999. Valves 6AL5 and 8 × 6AK5. **£10·00** plus 60p post, good condition.

**MODULATOR UNIT:** complete with transformer and 2 × 807 valves mounted in 19 in. chassis × 8 in. high × 8 in. deep. **£4·50** secondhand cond., or **£6·50** new cond. Carriage £1.

**RF UNIT:** suitable for use with the above unit. Complete with 2 × 3E29 valves. Ideal for conversion to 4 metres. **£5** secondhand cond., or **£7·50** new cond. Carriage £1.

**POWER SUPPLY UNIT PN-12A:** 230V a.c. input 50-60 c/s. 513V and 1025V @ 420 mA output. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament Transformer 230V a.c. input. 4 Rectifying Valves type 5Z3. 2 × 5V windings @ 3 Amps each, and 5V @ 6 Amp and 4V @ 0.25 Amp. Mounted on steel base 19″Wx11″Hx14″D. (All connections at the rear.) Excellent condition **£6·50** each, carr. £1.

**AUTO TRANSFORMER:** 230-115V, 50-60c/s, 1000 watts, mounted in a strong steel case 5″ × 6½″ × 7″. Bitumen impregnated. **£7** each, Carr. 75p. 230-115V, 50-60c/s, 500 watts. 7″ × 5″ × 5″. Mounted in steel ventilated case. **£4·00** each, Carr. 75p.

**MODULATOR UNIT:** 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, 75p carr.

**CATHODE RAY TUBE UNIT:** With 3in. tube, Type 3EG1 (CV1526) colour green, medium persistence complete with nu-metal screen, **£3·50** each, post 50p.

**APN-1 INDICATOR METER,** 270° Movement. Ideal for making rev. counter. **£1·25**, post 30p.

**AIRCRAFT SOLENOID UNIT S.P.S.T.:** 24V, 200 Amps, **£2** each, 30p post.
**DECADE RESISTOR SWITCH:** 0.1 ohm per step. 10 positions. 3 Gang, each, 0·9 ohms. Tolerance ± 1% **£3** each, 25p post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ± 1% **£3·50** each, post 30p.

**TF-1041B VALVE VOLTMETER:** Measures 25mV to 300V, 20 c/s to 1500 Mc/s a.c. Also 10mV to 1000V d.c. Resistance 0.02 ohms to 500 Meg. ohms. Power requirements 200-250 volts a.c. Secondhand, excellent con. **£35·00**. Carr. £1.

**VARIAC TRANSFORMERS:** Input 115V, output 0-135V at 2 Amps. **£3** each 75p post.

**RACK CABINETS:** (totally enclosed) for Std. 19 in. Panels. Size 6 ft. high × 21 in. wide × 16 in. deep, with rear door. **£12** each, £2·50 Carr. OR 4 ft. high × 23 in. wide × 19 in. deep, with rear door.**£8·50**, each, £2 Carr.

**INSTRUMENT CABINETS:** 19″W. × 16″H. × 16″D. **£5·00** + £1·25 carr. 19″W. × 10″D. × 5″H. **£2·50** + £1·00 carr.

**FUEL INDICATOR** Type 113R: 24V complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in 3in. diameter case. Price **£2** each, 30p post.

**TS-418/URM49 SIGNAL GENERATOR:** Covers 400-1000MHz range. CW Pulse or AM emission. Power Range 0-120 dbm. **£125** each. Carr. £1·50.

**TN/130/APR.9 UHF TUNING UNIT:** Freq. 4300-7350MHz. IF Output 160MHz with bandwidth of 20MHz and is electrically tuned by a d.c. reversible motor. **£27·50** each. Carr. £1.

**APR-4 AM RADIO RECEIVER:** 90-1000MHz. This receiver is suitable for monitoring and measuring frequencies as well as relative signal strength. Power Supply 115V 50c/s. **£100** each. Carr. £2.

**SIGNAL GENERATOR TS-497B/URR:** (Boonton). Freq. 2-400 Mc/s in 6 bands. Internal Mod. 400 or 1000 c/s per sec. External Mod. 50 to 10,000 c/s per sec. External PM. Percent Mod. 0-30 for sine wave. Am or Pulse Carrier. O/put Voltage 0·1-100,000 microvolts cont. variable. Impedance 50Ω. Price: **£85** each + £1·50 carr.

**CLASS "D" WAVEMETER NO. 1 MK. II:** Crystal controlled heterodyne frequency meter covering 2-8MHz. Power supply 6V d.c. Good secondhand cond. **£7·50** each. Post 60p.

**RCA TE-149 HETERODYNE WAVEMETER:** V-cut, 1MHz crystal (0·005%). Accuracy better than 0·02%. Dial directly calibrated every 1KHz from 2·5-5MHz. Useful harmonics up to 20MHz. Provision for fitting internal dry batteries. "As new" complete with Manual and Spares. **£14** each. Carr. 75p.

**POWER UNIT TYPE 24:** (for R.216 Receiver) A.C. operated 100-125V or 200-250V, 50c/s. "As new" **£10** each. Carr. 75p.

**ROTARY INVERTERS: TYPE PE.218E**—input 24-28V d.c., 80 Amps. 4,800 rpm. Output 115V a.c. 13 Amp 400 c/s. 1 Ph. P.F.9. **£17·50** each. Carr. £1·50.

**POWER SUPPLY:** 230V a.c. input; 3000V @ 2·5mA; 4v @ 1 Amp, 300-0-300 200mA; 6V @ 7 Amp; 6V @ 3 Amp. With smoothing capacitors etc. **£10·00** each. £1·50 carr.

**ACTUATOR UNIT:** With 115V d.c. geared motor; o/put 12·5 rpm; torque 16 ins. oz; reversible; microswitches and potentiometer. **£3·50** ea. + 40p post.
**DALMOTORS:** 24-28V d.c. at 45 Amps, 750 watts (approx. 1hp) 12,000rpm. **£5** each, 60p post.
**MOTOR:** 240V single phase, 2,400 rpm. 1/40 H.P. approx. Price **£1·75** each, 30p post.

**CONDENSERS:** 30 mfd 600 v wkg. d.c., **£3·50** each, post 50p. 10 mfd 600 v. **43p** each, 25p post. 8 mfd 2500 v. **£5** each, carr. 63p. 8 mfd 600 v. **43p** each, post 15p. 8 mfd. 1% 300 v. D.C. **£1·25**, post 25p, 4 mfd 3000 v. wkg. **£3** each, post **37p. 4** mfd 2000 v. **£2** each, post 25p. 4 mfd 600 v., 2 for **£1.** 0·01 mfd MICA 2·5Kv, **£1** for 5, post 10p. Capacitor 0·125 mfd, 27,000 v. wkg. **£3·75** each, 50p post. 2·25 mfd 25 Kv. wkg. **£20** each, £3 carr. 2 mfd 12·5 Kv wkg. TCC RL 7002-97 **£8·50** each, carr. £1. 10 mfd 3 Kv wkg. 55°C. TCC oil filled **£7·50** each, £1 carr. 5 x 1 mfd 3 Kv wkg. 55°C. **£6·50** each, £1 carr. 12 mfd 1500v d.c. wkg. **£3·50** each, 50p post.

**CONTROL PANEL:** 230 v. A.C., 24 v. D.C. @ 2 amps, **£2·50** each, carr. 75p.

**OHMITE VARIABLE RESISTOR:** 5 ohms, 5½ amps; or 40 ohms at 2·6 amps; 500 ohms, 0·55 amps. Price (either type) **£2** each, 30p post each.

**TX DRIVER UNIT:** Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete with filament transformer 230 v. A.C. Mounted in 19in. panel, **£4·50** each, carr. 75p.

**AR88 RECEIVER:** List of spares, 5p.

**TELEPRINTER EQUIPMENT, REPERFORATORS, READERS, and AUTO TRANSMITTERS ETC. Send for list, 5p.**

**REDIFON TELEPRINTER RELAY UNIT NO. 12:** ZA-41196 and power supply 200-250V a.c. Polarised relay type 3SEITR. 80-0-80V 25mA. Two stabilised valves CV 286. Centre Zero Meter 10-0-10. Size 8in. × 8in. × 8in. New condition **£7.50**, Carr. 75p.

**WESTON INDUSTRIAL THERMOMETER MODEL 221:** 0-100°C. 3in. dia. scale. Accuracy 1%. Precision made coil within-coil structure. Changes in temperature cause a rotary action of the Helix turning the shaft to which the pointer is mounted. **£2·80** each 30p post. Unused condition.

**TRANSMITTER UNITS:** Complete with 12V vibrator unit QQVO3-20A and 5 other valves with modulation transformer, etc. Two crystal controlled channels. Suitable for conversion to 2 metres. **£5** + £1 carr.

**THERMOCOUPLE METER:** Scale 3·5 AE 2in. square flush mounting. **£2·50** + 25p post.

**TS 15C/AP FLUXMETER:** Used to provide qualitative measurements of flux densities between pole faces of magnets. Range 1200-9600 gausses. ±2%. S/hand good cond. **£25** + 60p post.

**SYNCHRO DISTORTION AND MARGIN TEST SET:** (Onwood Type 4A2) S/hand excellent cond. **£85** each. Carr. £2.

**MASTER SYNCHRO TEST SET T.101031 (U.S.A.):** 115 volts 400 c/s. S/hand cond. **£15** each + £1 carr.

**MAGSLIP TESTER NO. 2 MK. I:** S/hand cond. **£25** each + £1 carr.

**SYNCHROS:** and other special purpose motors available. Send for list. S.A.E.

**PANORAMIC ADAPTOR TYPE ALA2:** Suitable for use with APR-1, APR-4, and other Receivers having an I.F. frequency of 30 MHz. Will display signals up to 5 MHz either side of the received frequency. Power Supply 115V a.c. 400 c/s. Tube 3PB1 with nu-metal screen. **£8·50** each. £1 carr. S/hand cond.

**MUIRHEAD PAMETRADA WAVE ANALYSER D-489-D:** Primarily used for the analysis of complex vibration waveforms, but will measure audio and power frequency waveforms from 19 c/s to 21 kc/s. Complete with power supply unit 230 volts 50 c/s. S/hand good cond. **£82·50** + £2 carr.

**D-652 L.F. MODULATOR:** Suitable for use with the above Wave Analyser D-489-D enabling the analysis of low frequencies between 2 and 20 c/s. S/hand good cond. **£25** each + £1. carr.

**AUTOMATIC VIBRATION EXCITER CONTROL UNIT TYPE 1016 Manufactured by Bruel & Kjoer.** 5-5000 c/s. per second. S/hand very good cond. **£90** + £2 carr.

**INSULATION TEST SETS:** A.C. or D.C. 0-5 kV. **£22·50.** S/hand cond. AND 0-3 kV. Positive and negative outputs, fine and course control. **£17·50.** S/hand cond. Carr. both types £2.

**INSULATION TEST SET:** 0-10 kV negative, earth with amplifier provision for checking ionisation. 110/230V a.c. input. S/hand good cond. **£30** + £1 carr.

**BOONTON SIGNAL GENERATOR TYPE 202B A.M./F.M.:** 54-216 MHz in three bands. Deviation 24, 80 and 240 kc/s. Attenuator is adjustable 0.1 Uv to 0.2V. As new condition. **£175** + £2 carr.

**AVO FIXED ATTENUATORS:** 75 ohms. **£2·50** + 20p post. New cond.

**R.F. POWER METER:** 0-30 watts s/hand good cond. **£27·50** + £1 carr.

**AVO VALVE TESTER AND CHARACTERISTIC METER:** S/hand good condition. **£35** each + £2 carr.

**AVO VALVE TESTER MK. III:** **£30** + £2 carr.

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**W. MILLS**

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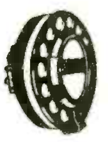

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| B79 | 4 | IN4007 Sil. Rec. diodes. 1,000 PIV lamp plastic | 55p |
| B81 | 10 | Reed Switches 1" long ⅛" dia. High speed P.O. type | 55p |
| B99 | 200 | Mixed Capacitors Approx. quantity, counted by weight. P & P 15p. | 55p |
| H4 | 250 | Mixed Resistors. Approx quantity counted by weight. P & P 15p. | 55p |
| H7 | 40 | Wirewound Resistors. Mixed types and values | 55p |
| H9 | 2 | OCP71 Light Sensitive Photo Transistor | 55p |
| H28 | 20 | OC200/1/2/3 PNP Silicon uncoded TO 5 can | 55p |
| H30 | 20 | 1 Watt Zener Diodes. Mixed Voltages 6.8–43V. | 55p |
| H35 | 100 | Mixed Diodes. Germ. Gold bonded etc. Marked and Unmarked. | 55p |
| H38 | 30 | Short lead Transistors. NPN Silicon Planar types | 55p |
| H39 | 6 | Integrated circuits. 4 Gates BMC 962. 2 Flip Flops BMC 945 | 55p |
| H40 | 20 | BFY50/2. 2N696. 2N1613 NPN Silicon uncoded TO-5 | 55p |
| H41 | 2 | Power Transistors Comp. Pair BD131/132 | 55p |

### UNMARKED UNTESTED PAKS

| | | | |
|---|---|---|---|
| B1 | 50 | Germanium Transistors PNP, AF and RF. | 55p |
| B66 | 150 | Germanium Diodes Min. glass type | 55p |
| B83 | 200 | Trans. manufacturers' rejects all types NPN, PNP, Sil. and Germ. | 55p |
| B84 | 100 | Silicon Diodes DO-7 glass equiv. to OA200, OA202 | 55p |
| B86 | 100 | Sil. Diodes sub. min. IN914 and IN916 types | 55p |
| H6 | 40 | 250mW Zener Diodes DO-7 Min. Glass Type | 55p |
| H15 | 30 | Top Hat Silicon Rectifiers. 750mA Mixed volts | 55p |
| H16 | 15 | Experimenters Pak of Integrated Circuits. Data supplied | 55p |
| H17 | 20 | 3 Amp. Silicon Stud Rectifiers. Mixed volts | 55p |
| H26 | 40 | NPN Silicon Trans. 2N3707-11 range, low noise amp. | 55p |
| H34 | 15 | Power Transistors, PNP, Germ. NPN Silicon TO-3 Can. P & P 5p extra. | 55p |

### MAKE A REV COUNTER FOR YOUR CAR

The 'TACHO BLOCK' This encapsulated block will turn any 0-1mA meter into a linear and accurate rev. counter for any car with normal coil ignition system.

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TYPE "A" PNP Silicon alloy, TO-5 can.
TYPE "B" PNP Silicon, plastic encapsulation.
TYPE "E" PNP Germanium AF or RF.
TYPE "F" NPN Silicon plastic encapsulation.
TYPE "G" NPN Silicon, similar ZTX300 range.
TYPE "H" PNP Silicon, similar ZTX500 range.

Various Types
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| CY31 | 0·40 |
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| DF96 | 0·40 |
| DK96 | 0·40 |
| DL92 | 0·32 |
| DL94 | 0·45 |
| DL96 | 0·40 |
| DM70 | 0·40 |
| DY86 | 0·29 |
| DY87 | 0·28 |
| DY802 | 0·30 |
| E88CC/01 | 1·08 |
| E180CC | 0·37 |
| E180CC | 0·90 |
| E182CC | 1·08 |
| EA50 | 0·18 |
| EABC80 | 0·27 |
| EAF42 | 0·46 |
| EB91 | 0·20 |
| EBC33 | 0·45 |
| EBC41 | 0·50 |
| ECC81 | 0·27 |
| EBF80 | 0·36 |
| EBF83 | 0·40 |
| EBF89 | 0·27 |
| ECC81 | 0·27 |
| ECC82 | 0·25 |
| ECC83 | 0·25 |
| ECC84 | 0·27 |
| ECC85 | 0·36 |
| ECC86 | 0·80 |
| ECC88 | 0·39 |
| ECC189 | 0·48 |
| ECF80 | 0·31 |
| ECF82 | 0·31 |
| ECF83 | 0·67 |
| ECF801 | 0·56 |
| ECH81 | 0·25 |
| ECH83 | 0·40 |
| ECH84 | 0·40 |
| ECL80 | 0·40 |

| | £ |
|---|---|
| ECL82 | 0·31 |
| ECL83 | 0·63 |
| ECL86 | 0·36 |
| EF36 | 0·50 |
| EF37A | 0·85 |
| EF40 | 0·62 |
| EF41 | 0·65 |
| EF80 | 0·25 |
| EF83 | 0·60 |
| EF85 | 0·31 |
| EF86 | 0·27 |
| EF89 | 0·25 |
| EF91 | 0·27 |
| EF92 | 0·31 |
| EF95 | 0·31 |
| EF183 | 0·26 |
| EF184 | 0·31 |
| EFL200 | 0·67 |
| EL34 | 0·59 |
| EL41 | 0·55 |
| EL84 | 0·21 |
| EL85 | 0·44 |
| EL86 | 0·36 |
| EL90 | 0·31 |
| EL95 | 0·36 |
| EL500 | 0·76 |
| EL504 | 0·76 |
| EM31 | 0·22 |
| EM80 | 0·36 |
| EM84 | 0·31 |
| EM87 | 0·63 |
| EY51 | 0·36 |
| EY86 | 0·40 |
| EY81 | 0·40 |
| EY88 | 0·40 |
| EZ41 | 0·45 |
| EZ80 | 0·22 |
| EZ81 | 0·24 |
| GZ34 | 0·52 |
| GZ37 | 0·63 |
| KT66 | 2·30 |
| KT88 | 2·25 |
| N78 | 1·60 |
| OA2 | 0·38 |

| | £ |
|---|---|
| OB2 | 0·35 |
| PABC80 | 0·35 |
| PC97 | 0·41 |
| PC900 | 0·42 |
| PCC84 | 0·36 |
| PCC89 | 0·45 |
| PCC189 | 0·49 |
| PCE800 | 0·75 |
| PCF80 | 0·25 |
| PCF82 | 0·27 |
| PCF84 | 0·54 |
| PCF86 | 0·50 |
| PCF200 | 0·60 |
| PCF201 | 0·60 |
| PCF801 | 0·44 |
| PCF802 | 0·45 |
| PCF805 | 0·80 |
| PCF806 | 0·65 |
| PCF808 | 0·85 |
| PCH200 | 0·65 |
| PCL81 | 0·50 |
| PCL82 | 0·30 |
| PCL83 | 0·60 |
| PCL84 | 0·35 |
| PCL85 | 0·40 |
| PCL86 | 0·43 |
| PFL200 | 0·60 |
| PL36 | 0·50 |
| PL81 | 0 40 |
| PL82 | 0·35 |
| PL83 | 0·36 |
| PL84 | 0·30 |
| PL500 | 0·62 |
| PL504 | 0·62 |
| PL508 | 0·70 |
| PL509 | 1·05 |
| PL802 | 0·88 |
| PX4 | 2·50 |
| PY33 | 0·55 |
| PY80 | 0·35 |
| PY81 | 0·30 |
| PY82 | 0·30 |
| PY83 | 0·35 |
| PY88 | 0·32 |
| PY800 | 0·35 |
| PY801 | 0·45 |
| QQVO 3-10 | 1·10 |

| | £ |
|---|---|
| R17 | 0·45 |
| R19 | 0·35 |
| STV 280/40 | 3·20 |
| STV 280/80 | 8·20 |
| TT21 | 3·80 |
| U25 | 0·70 |
| U26 | 0·70 |
| U27 | 0·45 |
| U191 | 0·68 |
| U801 | 0·70 |
| UABC80 | 0·30 |
| UAF42 | 0·50 |
| UBC41 | 0·48 |

| | £ |
|---|---|
| UBF80 | 0·35 |
| UBF89 | 0·34 |
| UCC85 | 0·35 |
| UCF80 | 0·60 |
| UCH42 | 0·60 |
| UCH81 | 0·35 |
| UCL82 | 0·35 |
| UCL83 | 0·55 |
| UF80 | 0·30 |
| UF89 | 0·35 |
| UL41 | 0·60 |
| UL84 | 0·35 |
| UU5 | 0·65 |
| UY41 | 0·45 |
| UY85 | 0·35 |
| VR105/30 | 0·35 |

| | £ |
|---|---|
| VR150/30 | 0·35 |
| 2800U | 1·40 |
| Z801U | 1·40 |
| Z803U | 1·10 |
| Z900T | 0·90 |
| 1L4 | 0·13 |
| 1R5 | 0·35 |
| 1S4 | 0 30 |
| 1S5 | 0·30 |
| 1T4 | 0·30 |
| 1X2A | 0·36 |
| 1X2B | 0·50 |
| 2K25 | 7·50 |
| 3A4 | 0·40 |
| 3D6 | 0·15 |
| 3Q4 | 0·55 |
| 3S4 | 0·33 |
| 3V4 | 0·48 |

| | £ |
|---|---|
| 5B254M | 2·75 |
| 5B/255M | 3·10 |
| 5R4GY | 0·65 |
| 5U4G | 0·30 |
| 5V4G | 0·45 |
| 5Y4G | 0·35 |
| 5Y3GT | 0·35 |
| 5Z3 | 0·70 |
| 5Z4 | 0·75 |
| 5Z4GT | 0·32 |
| 6AB7 | 0·25 |
| 6AC7 | 0·45 |
| 6AH6 | 0·50 |
| 6AK5 | 0·35 |
| 6AK8 | 0·30 |
| 6AL5 | 0·18 |
| 6AL5W | 0·35 |
| 6AM6 | 0·35 |
| 6AN8 | 0·60 |

| | £ |
|---|---|
| 6AQ5 | 0·36 |
| 6AQ5W | 0·45 |
| 6A86 | 0·30 |
| 6AT6 | 0·30 |
| 6AU6 | 0·20 |
| 6AX4GT | 0·50 |
| 6AX5GT | 0·60 |
| 6B7 | 0·35 |
| 6BK7 | 0·60 |
| 6BA6 | 0·25 |
| 6BE6 | 0·25 |
| 6BG6G | 0·47 |
| 6BJ6 | 0·45 |
| 6BQ7A | 0·43 |
| 6BR7 | 1·09 |
| 6BW6 | 0·80 |
| 9BW7 | 0·80 |

| | £ |
|---|---|
| 6C4 | 0·25 |
| 6C6 | 0·20 |
| 6CH6 | 0·55 |
| 6CL6 | 0·50 |
| 6D6 | 0·15 |
| 6EA8 | 0·60 |
| 6F23 | 0·80 |
| 6F33 | 1·35 |
| 6H6M | 0·25 |
| 6J4WA | 0·65 |
| 6J5 | 0·35 |
| 6J5GT | 0·30 |
| 6J6 | 0·25 |
| 6J7G | 0·30 |
| 6J7M | 0·35 |
| 6K6GT | 0·55 |
| 6K7 | 0·40 |

| | £ |
|---|---|
| 6K7G | 0·17 |
| 6K8GT | 0·40 |
| 6K25 | 0·70 |
| 6L6M | 1·35 |
| 6SA7 | 0·40 |
| 6SA7GT | 0·25 |
| 6SC7GT | 0·20 |
| 6SG7 | 0·40 |
| 6SJ7 | 0·40 |
| 6SJ7GT | 0·28 |
| 6SK7 | 0·45 |
| 6SL7GT | 0·35 |
| 6SN7GT | 0·35 |
| 6SQ7 | 0·45 |
| 6SQ7GT | 0·30 |
| 6V6G | 0·15 |
| 6V6GT | 0·35 |
| 6X4 | 0·33 |
| 6X5G | 0·25 |
| 6X5GT | 0·35 |
| 6Y6G | 0·75 |
| 6-30L2 | 0·85 |
| 6Z4 | 0·40 |
| 7B7 | 0·50 |
| 7Y4 | 0·60 |
| 9D6 | 0·30 |
| 11E2 | 3·70 |
| 12AT6 | 0·35 |
| 12AT7 | 0·35 |
| 12AU7 | 0·24 |
| 12AV6 | 0·40 |
| 12AX7 | 0·25 |
| 12BA6 | 0·25 |
| 12BE6 | 0·35 |
| 12BH7 | 0·23 |
| 12C8 | 0·30 |
| 12E1 | 2·85 |
| 12K5 | 0·95 |
| 12K7GT | 0·45 |
| 12K8GT | 0·40 |
| 12Q7GT | 0·40 |
| 12SG7 | 0·40 |
| 1487 | 0·70 |
| 19AQ5 | 0·40 |
| 19G3 | 5·75 |
| 19G6 | 5·75 |
| 19H4 | 5·25 |
| 20P4 | 1·00 |
| 25L6GT | 0·50 |

# COLOMOR

**THE VALVE WITH A GUARANTEE**

| | £ |
|---|---|
| 30C15 | 0·70 |
| 30C17 | 0·85 |
| 30C18 | 0·75 |
| 30F5 | 0·80 |
| 30FL1 | 0·70 |
| 30FL12 | 0·95 |
| 30FL14 | 0·80 |
| 30L15 | 0·80 |
| 30L17 | 0·80 |
| 30P12 | 0·75 |
| 30P19 | 0·70 |
| 30PL1 | 0·70 |
| 30OL13 | 0·90 |
| 30PL14 | 0·85 |
| 35L6GT | 0·50 |
| 35W4 | 0·30 |
| 36Z4GT | 0·55 |
| 50C5 | 0·45 |
| 50CD6G | 1·10 |
| 50EH5 | 0·55 |
| 75 | 0·50 |
| 76 | 0·55 |
| 78 | 0·50 |
| 80 | 0·55 |
| 723A/B | 7·00 |
| 803 | 5·50 |
| 805 | 12·00 |
| 807 | 0·50 |
| 813 | 4·00 |
| 832A | 2·70 |
| 866A | 1·25 |
| 931A | 4·75 |
| 954 | 0·35 |
| 955 | 0·35 |
| 956 | 0·30 |
| 957 | 0·35 |
| 991 | 0·40 |
| 2051 | 0·70 |
| 5933 | 1·00 |

| | £ |
|---|---|
| 6057 | 0·55 |
| 6060 | 0·50 |
| 6064 | 0·45 |
| 6065 | 0·65 |
| 6080 | 1·55 |
| 6146 | 1·75 |
| 8020 | 3·75 |
| 9001 | 0·15 |
| 9002 | 0·40 |
| 9003 | 0·45 |
| 9004 | 0·12 |
| 9006 | 0·12 |

**C.R. Tubes**

| | |
|---|---|
| VCR97 | 4·00 |
| VCR517R | 5·00 |
| VCR517C | 7·00 |
| 88D | 8·10 |
| 88J | 8·10 |
| 88L | 8·10 |

**Photo Tubes**

| | |
|---|---|
| CMG25 | 2·50 |
| 931A | 4·75 |
| 6097C | 16·00 |

**Special Valves**

| | |
|---|---|
| CV2339 | 18·00 |
| JP9/7D | 35·00 |
| K301 | 4·50 |
| K305 | 11·00 |
| K308 | 14·50 |
| K337 | 14·50 |
| KRN2A | 3·15 |
| WL417A | 1·35 |
| 3J/92/E | 35·00 |
| 5C22 | 22·00 |
| 714AY | 3·60 |
| 725A | 22·50 |

**SPECIAL OFFER O9J TUBE £2·50** p & p 50p

# TRANSISTORS, ZENER DIODES

| | £ |
|---|---|
| OA5 | 0·20 |
| OA10 | 0·25 |
| OA70 | 0·10 |
| OA71 | 0·10 |
| OA73 | 0·07 |
| OA74 | 0·07 |
| OA79 (6D15) | 0·10 |
| OA81 | 0·08 |
| OA91 | 0·07 |
| OA200 | 0·07 |
| OA202 | 0·10 |
| OAZ200 | 0·55 |
| OAZ201 | 0·50 |
| OC22 | 0·50 |
| OC25 | 0·40 |
| OC26 | 0·25 |
| OC28 | 0·60 |
| OC29 | 0·60 |
| OC35 | 0·50 |
| OC36 | 0·56 |
| OC38 | 0·42 |
| OC44 | 0·17 |
| OC45 | 0·12 |
| OC70 | 0·12 |

| | £ |
|---|---|
| OC71 | 0·12 |
| OC72 | 0·20 |
| OC73 | 0·30 |
| OC75 | 0·25 |
| OC76 | 0·25 |
| OC81 | 0·20 |
| OC81D | 0·20 |
| OC81DM | 0·20 |
| OC82 | 0·25 |
| OC82DM | 0·30 |
| OC83 | 0·25 |
| OC83B | 0·15 |
| OC84 | 0·25 |
| OC122 | 0·50 |
| OC139 | 0·25 |
| OC140 | 0·40 |
| OC170 | 0·25 |
| OC171 | 0·30 |
| OC172 | 0·37 |
| OC200 | 0·40 |
| OC201 | 0·75 |
| OC206 | 0·95 |
| 1N21B | 0·30 |
| 1N25 | 0·60 |
| 1N43 | 0·10 |
| 1N70 | 0·07 |
| 1N677 | 0·12 |

| | £ |
|---|---|
| 1N702-725 | 0·36 |
| 1N823A | 1·30 |
| 1N4785 | 0·85 |
| 1ZMT5 | 0·35 |
| 1ZMT10 | 0·33 |
| 1ZT5 | 0·67 |
| 1ZT10 | 0·63 |
| 2G385 | 0·51 |
| 2G403 | 0·51 |
| 2N918 | 0·37 |
| 2N1304 | 0·22 |
| 2N1306 | 0·25 |
| 2N1307 | 0·25 |
| 2N2147 | 0·64 |
| 2N2411 | 1·50 |
| 2N2904A | 0·25 |
| 2N2989 | 4·00 |
| 2N3053 | 0·20 |
| 2N3054 | 0·50 |
| 2N3055 | 0·64 |
| 2N3730 | 0·50 |
| 2N3731 | 2·75 |
| 2N4172 | 0·50 |
| S2303 | 0·50 |
| 3F100 | 0·62 |
| 3FR5 | 0·32 |
| 3N128 | 0·87 |

| | £ |
|---|---|
| 3N139 | 1·75 |
| 3N140 | 0·97 |
| 3N154 | 0·95 |
| 3N159 | 1·45 |
| 6FR5 | 0·45 |
| 12FR60 | 0·73 |
| 40954 | 1·25 |
| 40595 | 1·25 |
| 40636 | 1·25 |
| 40668 | 1·25 |
| 40669 | 1·40 |
| AC126 | 0·25 |
| AC127 | 0·25 |
| AC128 | 0·20 |
| AC176 | 0·20 |
| ACY17 | 0·25 |
| ACY28 | 0·17 |
| AD149 | 0·50 |
| AD161 | 0·35 |
| AD162 | 0·35 |
| AF118 | 0·50 |
| AF127 | 0·20 |
| AF139 | 0·30 |
| AF178 | 0·48 |
| AF186 | 0·40 |
| ASY26 | 0·25 |
| ASY28 | 0·25 |

| | £ |
|---|---|
| ASY67 | 0·48 |
| BAW19 | 0·28 |
| BC107 | 0·10 |
| BC108 | 0·10 |
| BC113 | 0·10 |
| BC118 | 0·20 |
| BCY72 | 0·15 |
| BF115 | 0·25 |
| BF173 | 0·20 |
| BFY51 | 0·20 |
| BFY52 | 0·20 |
| BS | 0·45 |
| BS2 | 0·47 |
| BSY29 | 0·25 |
| BU100 | 1·80 |
| BYZ13 | 0·25 |
| BYZ16 | 0·63 |
| CRS1/10 | 0·25 |
| CRS1/20 | 0·38 |
| CRS1/30 | 0·40 |
| CRS1/35 | 0·43 |
| CRS1/40 | 0·48 |
| CRS3/05 | 0·30 |
| CRS3/20 | 0·38 |
| CRS3/30 | 0·43 |
| CR825/025 | 0·55 |

| | £ |
|---|---|
| CRS3/40 | 0·50 |
| C82A | 0·65 |
| CV102 | 0·25 |
| GET103 | 0·23 |
| GET115 | 0·45 |
| GET116 | 0·50 |
| GEX66 | 1·50 |
| NKT222 | 0·20 |
| NKT304 | 0·50 |
| RAS310AF | 0·33 |
| 8D918 | 0·26 |
| 8D928 | 0·31 |
| 8D938 | 0·32 |
| 8D94 | 0·21 |
| 8D98S | 0·46 |
| V405A | 0·40 |
| Z2A51CF | 0·78 |
| ZR11 | 0·33 |
| ZR21 | 0·46 |
| ZR22 | 0·42 |

**ZENER DIODES**

All preferred voltage

| | |
|---|---|
| ½W | 0·17 |
| 1W | 0·37 |
| 1·5W | 0·25 |
| 7W | 0·40 |

*MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. U.K. POSTAGE over £3 free, 5p for one valve plus 1p for each additional valve or transistor. C.O.D. 25p extra.*

## VALVES AND TRANSISTORS

Telephone enquiries for valves, transistors, etc., retail 743 4946; trade and export 743 0899.

## MARCONI TEST EQUIPMENT

**TF1041C** VTVM A.C. voltage range 300 MV to 300V in 7 ranges, 20 Hz-1500 MHz. D.C. voltage ranges 300 MV 1000V in 8 ranges. D.C. resistance 50 ohms to 500 ohms. Price **£62·50.**

**TF 801B/3/S SIGNAL GENERATOR**
Spec. as for TF 801D/1/S except for minor circuit changes e.g. 1 and 2 MHz switched calibrator. P.O.A.

**TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT.** For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. frequ. 10Hz to 100 kHz, pulse width 0·1 to 100μ sec., delay −1·5 to +3000μ sec., rise time < 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25μ sec, delay 0 to + 300μ sec. **£230.**

**TF 801D/1/S SIGNAL GENERATOR.** Range 10-485 MHz in five ranges. R.F. output 0·1 μV-IV source e.m.f. Dial calibrated in volts, decibels and power relative to thermal noise. Piston type attenuator. 50Ω output Impedance. Internal modulation at 1 kHz at up to 90% depth, also external sine and pulse modulation. Built-in 5MHz crystal calibrator. Separate R.F. and mod. meters. P.O.A.

**TF 562B/3** Oscillator and Detector Unit.

**TF 1226B**, **TF 1225A**, **TM 577A** } White Noise Test Set.

**TF 1258A VHF SPECTRUM ANALYSER** for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (a) 85-175 μSec, (b) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2μV to 20mV with ×10 multiplier. **£200.**

**RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)**
8 digit in-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Three independent inputs, self-check etc. Full spec. and price on request.

**SIGNAL GENERATOR TYPE AN/USM-16 (MODEL BJ75A)**
A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs of **CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db) **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
Brief specifications, Frequency 10 to 440MHz, RF output 0.1uV to 0.224V at 50 ohms. Modes of operation CW-HI, CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0.75 kHzdev., S.F.M. —x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M. —50 to 5000 pps at 1 to 30μsec. width int. or ext., 150 to 5000Hz rep rate. 3 meters for; mod. and dev., frequency discrimination pulse level output. With manual. Complete specification and price on application.

**HEWLETT—PACKARD 185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN.** Full spec. and P.O.A.

**5248 COUNTER FREQUENCY MEASUREMENT:** 10Hz to 10,1MHz. Accuracy ± 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz, **525B** 100 to 220MHz, **526A** video amplifier. Price on application.

**540B TRANSFER OSCILLATOR.** Extends range of 524 and 5245 series counters to 18 gHz, or on its own, measures frequencies below 4gHz with 0.5% accuracy.

**430C MICROWAVE POWER METER.** Complete with **476A** bolo mount, **475B** tunable bolo, **BM16** waveguide, **£95.**

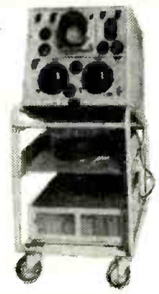
**205AG AUDIO OSCILLATOR.** Low distortion, 20 Hz to 200 kHz, metered and attenuated inputs and outputs enabling a very wide range of measurements to be made on amplifiers, filters, etc. **£125.**

**616B SHF SIGNAL GENERATOR.** Freq. range 1,75GHz-4,2GHz. Mod.: F.M., C.W Pulse and Ext. A.M., output: 0,1uV-200mV Price on application

**TF 894 AUDIO TESTER.** Combined A.F. Generator (0-25kHz), Output meter (up to 2W. at 600, 15 and 3Ω,) and valve voltmeter (0-800V., with stepped and variable attenuators. **£60.**

**BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.**

**SPECTRUM ANALYSER TYPEOA1094**
Freq. range: 3 to 30MHz in 9 bands. Selectivity: 6 30 and 150Hz, at 3db. Spectrum width: 0-30kHz. Sweep Duration: 0.1, 0,3, 1, 3, 10 & 30 secs.
Complete as illustrated, with manuals, etc. and **L.F. Adaptor.**
Price upon application.



**SOLATRON DO 905 STABILISED AMPLITUDE SIGNAL GENERATOR.** Freq. range 350kHz-50MHz £70.

**TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE.** Freq.: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: −50d8 to +10dB. Impedance: 75, 100, 600Ω. Price upon application.

**BC 624 RECEIVER** (Part of SCR 522 TX/RX) 100-156 mcs, no valves, requires separate PSU for 28V. £2.50. Carriage 50p.

**TR 143 TRANSMITTER RECEIVER** 100/1261mcs, requires separate PSU for 28V. Price £12.00. Carriage £1.50.

**TEKTRONIX OSCILLOSCOPES.**
**541A**—33MHz, plug-in Y amps.
**531-57**—60MHz, separate P.S.U.
**561A**—10MHz, solid state, compact, takes the following plugs-ins: X, Y, differential, sampling, spectrum analyser.

**PLUG-IN UNITS**
**CA**—24 MHz dual trace 50MV-20V.
**G**—20 MHz differential 50MV-20V.
**L**—30 MHz fast rise time 5MV-20V.
**D**—High gain differential 1MV-50V.
**N** 600MHz sampling 10mV-cm.
**R** Transistor measurement.
**P** type callibration.
**3A1**—Dual trace 10mV-10V.
**3B3**—Delayed sweep time base.
**134**—P6021 probe and current probe amplifier, 1mA-15A p. & p., new and boxed, **£125.**

**EQUIPMENT**
**162** wave form generator.
**163** Pulse generator.

**500/250W MEDIUM WAVE BROADCAST TRANSMITTERS.** Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) **£8·50.** P. & P. £1·50.

**AR88 SPARES.** We hold the largest stock in U.K. Write for list.

**3 PHASE AUTO TRANSFORMER,** wye input 400v, wye output 241.5/230/218.5v 50c 18kVA. Made by Westinghouse of USA. Brand new in original cases £60.00 including UK transport.

# PLEASE NOTE

Unless offered as "as seen"

# ALL EQUIPMENT

ordered from us is completely overhauled mechanically and electrically in our own laboratories

**FOR EXPORT ONLY**
**TRANSMITTERS:**
BC 610 Hallicrafters.
RCA ET 4336 also modified version of increased output to 700w.
COLLINS TYPE 231D 4/5kw., 10 channel, autotone and manual tuning. All above complete installation and spare parts.
**TRANSCEIVERS**
19, 19HP, 38, 62.
C-11 TRANSMITTERS
C-13 TRANSMITTERS

**SEE OUR SALE on page xx**

## V.A.T.

**PLEASE ADD 10% TO ALL ORDERS**

**REMSCOPE TYPE 741 STORAGE OSCILLOSCOPE.** On trolley, complete with plug-in trace shifter and two plug-in Y amplifiers. **£180** plus carriage.

**HARNESS "A" & "B"** control units, junction boxes, headphones, microphones, etc.

**R.F. METER** 0-8 amp. 2¼" (U.S.A.) **£1·80** P. & P. 15p.

**29/41FT. AERIALS** each consisting of ten 3ft., ⅞in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag. £7·50 new or £4·50 slightly used. Carriage 50p.

**METERS** Full List of our very large stock of meters on request.

**TELEPHONE TYPE "J"** (Tropicalised) 10 line **MAGNETO TELEPHONE SWITCHBOARD**

50 line **AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD**

Price of each of the above on application.

**RADAR SCANNER ASSEMBLY TYPE C368** Parabolic assembly 17". Complete with motor for 26V 600W, etc. £22·50. Carriage £2·50.

★ **Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.** ★

**TELEPHONE ENQUIRIES** relating to **TEST EQUIPMENT** should be made to 01-748 8006 Extension 23.
To view **TEST EQUIPMENT** please phone for appointment

**COLOMOR (ELECTRONICS LTD.)**
**170 Goldhawk Rd., London, W.12**
**Tel. 01 - 743 0899**

# BRAND NEW SEMICONDUCTORS & COMPONENTS GUARANTEED

**WE SUPPLY NEARLY ALL THE COMPONENTS FOR PROJECTS ADVERTISED IN THIS MAGAZINE**

## TRANSISTORS

| | |
|---|---|
| 2G301 | 0·15 |
| 2G302 | 0·15 |
| 2G303 | 0·25 |
| 2G306 | 0·30 |
| 2G309 | 0·30 |
| 2G345B | 0·25 |
| 2G371 | 0·15 |
| 2G374 | 0·15 |
| 2N174 | 1·40 |
| 2N404 | 0·23 |
| 2N456 | 0·75 |
| 2N456A | 0·75 |
| 2N457A | 0·80 |
| 2N491 | 3·25 |
| 2N696 | 0·15 |
| 2N697 | 0·15 |
| 2N698 | 0·25 |
| 2N699 | 0·29 |
| 2N706 | 0·10 |
| 2N706A | 0·12 |
| 2N708 | 0·13 |
| 2N709 | 0·40 |
| 2N711 | 0·30 |
| 2N718 | 0·21 |
| 2N718A | 0·30 |
| 2N720 | 0·50 |
| 2N721 | 0·55 |
| 2N914 | 0·15 |
| 2N916 | 0·17 |
| 2N918 | 0·30 |
| 2N929 | 0·14 |
| 2N930 | 0·14 |
| 2N1090 | 0·23 |
| 2N1091 | 0·24 |
| 2N1131 | 0·20 |
| 2N1132 | 0·20 |
| 2N1302 | 0·16 |
| 2N1303 | 0·16 |
| 2N1304 | 0·20 |
| 2N1305 | 0·20 |
| 2N1306 | 0·22 |
| 2N1307 | 0·22 |
| 2N1308 | 0·25 |
| 2N1309 | 0·37 |
| 2N1483 | 0·90 |
| 2N1507 | 0·24 |
| 2N1613 | 0·20 |
| 2N1631 | 0·35 |
| 2N1637 | 0·36 |
| 2N1638 | 0·32 |
| 2N1701 | 1·10 |
| 2N1702 | 2·15 |
| 2N1711 | 0·22 |
| 2N1893 | 0·34 |
| 2N2102 | 0·30 |
| 2N2147 | 0·70 |
| 2N2148 | 0·94 |
| 2N2192 | 0·40 |
| 2N2192A | 0·40 |
| 2N2193 | 0·40 |
| 2N2193A | 0·61 |
| 2N2194 | 0·27 |
| 2N2194A | 0·30 |
| 2N2195 | 0·37 |
| 2N2195A | 0·18 |
| 2N2218A | 0·30 |
| 2N2219 | 0·37 |
| 2N2219A | 0·51 |
| 2N2220 | 0·20 |
| 2N2221 | 0·20 |
| 2N2221A | 0·33 |
| 2N2222 | 0·31 |
| 2N2222A | 0·41 |
| 2N2368 | 0·11 |
| 2N2369 | 0·15 |
| 2N2369A | 0·17 |
| 2N2646 | 0·50 |
| 2N2647 | 1·20 |
| 2N2711 | 0·12 |
| 2N2712 | 0·12 |
| 2N2713 | 0·17 |
| 2N2714 | 0·17 |
| 2N2904 | 0·28 |
| 2N2904A | 0·25 |
| 2N2905 | 0·33 |
| 2N2905A | 0·35 |
| 2N2906 | 0·24 |
| 2N2906A | 0·30 |
| 2N2907 | 0·32 |
| 2N2907A | 0·33 |
| 2N2923 | 0·12 |
| 2N2924 | 0·12 |
| 2N2925 | 0·15 |
| 2N2926 | |
| Green | 0·12 |
| Yellow | 0·10 |
| Orange | 0·10 |
| 2N3053 | 0·31 |
| 2N3054 | 0·60 |
| 2N3055 | 0·50 |
| 2N3390 | 0·20 |
| 2N3391 | 0·20 |
| 2N3391A | 0·22 |
| 2N3392 | 0·13 |
| 2N3393 | 0·12 |
| 2N3394 | 0·17 |
| 2N3402 | 0·12 |

| | |
|---|---|
| 2N3403 | 0·19 |
| 2N3404 | 0·24 |
| 2N3405 | 0·27 |
| 2N3414 | 0·10 |
| 2N3415 | 0·10 |
| 2N3416 | 0·15 |
| 2N3417 | 0·21 |
| 2N3570 | 1·25 |
| 2N3571 | 1·12 |
| 2N3572 | 0·97 |
| 2N3702 | 0·11 |
| 2N3703 | 0·10 |
| 2N3704 | 0·14 |
| 2N3705 | 0·10 |
| 2N3706 | 0·09 |
| 2N3707 | 0·10 |
| 2N3708 | 0·70 |
| 2N3709 | 0·09 |
| 2N3710 | 0·12 |
| 2N3711 | 0·09 |
| 2N3712 | 0·95 |
| 2N3713 | 1·08 |
| 2N3714 | 1·15 |
| 2N3715 | 1·23 |
| 2N3716 | 1·30 |
| 2N3773 | 3·00 |
| 2N3779 | 3·15 |
| 2N3790 | 2·20 |
| 2N3791 | 2·06 |
| 2N3792 | 2·20 |
| 2N3794 | 0·10 |
| 2N3819 | 0·32 |
| 2N3820 | 0·47 |
| 2N3823 | 0·62 |
| 2N3824 | 0·75 |
| 2N3826 | 0·23 |
| 2N3854 | 0·16 |
| 2N3854A | 0·16 |
| 2N3855 | 0·16 |
| 2N3855A | 0·16 |
| 2N3856 | 0·16 |
| 2N3856A | 0·16 |
| 2N3858 | 0·16 |
| 2N3858A | 0·16 |
| 2N3859 | 0·16 |
| 2N3859A | 0·16 |
| 2N3860 | 0·16 |
| 2N3866 | 0·70 |
| 2N3877 | 0·25 |
| 2N3877A | 0·26 |
| 2N3900 | 0·20 |
| 2N3900A | 0·21 |
| 2N3901 | 0·32 |
| 2N3903 | 0·22 |
| 2N3904 | 0·17 |
| 2N3905 | 0·21 |
| 2N3906 | 0·20 |
| 2N4036 | 0·46 |
| 2N4037 | 0·40 |
| 2N4058 | 0·16 |
| 2N4059 | 0·09 |
| 2N4060 | 0·11 |
| 2N4061 | 0·11 |
| 2N4062 | 0·11 |
| 2N4302 | 0·25 |
| 2N4303 | 0·47 |
| 2N4916 | 0·20 |
| 2N4917 | 0·17 |
| 2N4918 | 0·50 |
| 2N4919 | 0·63 |
| 2N4920 | 0·71 |
| 2N4921 | 0·50 |
| 2N4922 | 0·55 |
| 2N4923 | 0·60 |
| 2N5172 | 0·12 |
| 2N5174 | 0·22 |
| 2N5175 | 0·26 |
| 2N5176 | 0·32 |
| 2N5190 | 0·92 |
| 2N5191 | 0·96 |
| 2N5192 | 1·24 |
| 2N5193 | 1·01 |
| 2N5194 | 1·10 |
| 2N5195 | 1·46 |
| 2N5245 | 0·35 |
| 2N5457 | 0·35 |
| 2N5458 | 0·33 |
| 2N5459 | 0·33 |
| 3N128 | 0·73 |
| 3N138 | 1·65 |
| 3N139 | 1·42 |
| 3N140 | 0·92 |
| 3N141 | 0·81 |
| 3N142 | 0·58 |
| 3N143 | 0·75 |
| 3N152 | 0·92 |
| 3N153 | 0·81 |
| 3N154 | 0·84 |
| 3N159 | 1·17 |
| 3N187 | 1·55 |
| 3N200 | 2·49 |
| 3N201 | 1·05 |
| 40050 | 0·78 |
| 40251 | 0·81 |
| 40309 | 0·30 |
| 40310 | 0·50 |
| 40313 | 0·92 |

| | |
|---|---|
| 40316 | 0·50 |
| 40318 | 0·92 |
| 40360 | 0·46 |
| 40361 | 0·43 |
| 40362 | 0·45 |
| 40363 | 0·88 |
| 40389 | 0·46 |
| 40394 | 0·56 |
| 40395 | 0·65 |
| 40406 | 0·44 |
| 40407 | 0·33 |
| 40408 | 0·50 |
| 40409 | 0·52 |
| 40410 | 0·53 |
| 40411 | 2·00 |
| 40414 | 3·55 |
| 40467 | 0·69 |
| 40468A | 0·44 |
| 40600 | 0·69 |
| 40601 | 0·67 |
| 40602 | 0·46 |
| 40603 | 0·58 |
| 40604 | 0·56 |
| 40636 | 1·10 |
| 40673 | 0·70 |
| AC107 | 0·35 |
| AC113 | 0·16 |
| AC115 | 0·16 |
| AC117 | 0·20 |
| AC121 | 0·13 |
| AC126 | 0·25 |
| AC127 | 0·20 |
| AC128 | 0·20 |
| AC141K | 0·30 |
| AC142K | 0·25 |
| AC151V | 0·14 |
| AC152V | 0·17 |
| AC153 | 0·22 |
| AC153K | 0·25 |
| AC154 | 0·20 |
| AC176 | 0·18 |
| AC176K | 0·20 |
| AC187K | 0·20 |
| AC188K | 0·26 |
| ACY17 | 0·35 |
| ACY18 | 0·24 |
| ACY19 | 0·27 |
| ACY20 | 0·22 |
| ACY21 | 0·26 |
| ACY22 | 0·16 |
| ACY28 | 0·20 |
| ACY30 | 0·42 |
| ACY39 | 0·65 |
| ACY40 | 0·17 |
| ACY41 | 0·17 |
| ACY44 | 0·31 |
| AD136V | 0·96 |
| AD142 | 0·54 |
| AD143 | 0·45 |
| AD149V | 0·66 |
| AD150 | 0·63 |
| AD161 | 0·45 |
| AD162 | 0·45 |
| AD161 } | Pr. |
| AD162 } | 1·05 |
| AF109R | 0·40 |
| AF114 | 0·25 |
| AF115 | 0·24 |
| AF116 | 0·25 |
| AF117 | 0·20 |
| AF118 | 0·50 |
| AF121 | 0·22 |
| AF124 | 0·24 |
| AF125 | 0·20 |
| AF126 | 0·19 |
| AF127 | 0·20 |
| AF139 | 0·38 |
| AF170 | 0·25 |
| AF172 | 0·25 |
| AF178 | 0·55 |
| AF179 | 0·65 |
| AF180 | 0·50 |
| AF186 | 0·40 |
| AF200 | 0·35 |
| AF211 | 0·55 |
| AF239 | 0·41 |
| AF240 | 0·72 |
| AF279 | 0·54 |
| AF280 | 0·54 |
| AFY42 | 0·74 |
| AL102 | 0·75 |
| AL103 | 0·70 |
| ASY26 | 0·30 |
| ASY27 | 0·36 |
| ASY28 | 0·28 |
| ASY29 | 0·36 |
| ASY50 | 0·20 |
| ASY55 | 0·35 |
| AU103 | 1·25 |
| BC107 | 0·10 |
| BC108 | 0·10 |
| BC109 | 0·10 |
| BC113 | 0·13 |
| BC114 | 0·12 |
| BC115 | 0·15 |
| BC116 | 0·15 |
| BC116A | 0·18 |
| BC117 | 0·21 |
| BC118 | 0·11 |
| BC119 | 0·27 |

| | |
|---|---|
| BC121 | 0·23 |
| BC125 | 0·15 |
| BC126 | 0·20 |
| BC132 | 0·50 |
| BC134 | 0·11 |
| BC135 | 0·11 |
| BC136 | 0·15 |
| BC137 | 0·15 |
| BC138 | 0·24 |
| BC140 | 0·34 |
| BC141 | 0·39 |
| BC142 | 0·24 |
| BC143 | 0·21 |
| BC144 | 0·24 |
| BC145 | 0·21 |
| BC147 | 0·12 |
| BC148 | 0·12 |
| BC149 | 0·12 |
| BC153 | 0·18 |
| BC154 | 0·18 |
| BC157 | 0·14 |
| BC158 | 0·13 |
| BC159 | 0·14 |
| BC160 | 0·37 |
| BC167B | 0·11 |
| BC168B | 0·13 |
| BC168C | 0·13 |
| BC169B | 0·13 |
| BC169C | 0·11 |
| BC170 | 0·11 |
| BC171 | 0·13 |
| BC172 | 0·11 |
| BC182 | 0·10 |
| BC182L | 0·12 |
| BC183 | 0·09 |
| BC183L | 0·09 |
| BC184 | 0·11 |
| BC184L | 0·11 |
| BC186 | 0·25 |
| BC187 | 0·25 |
| BC207 | 0·12 |
| BC208 | 0·11 |
| BC212K | 0·10 |
| BC212L | 0·18 |
| BC214L | 0·21 |
| BC237 | 0·09 |
| BC238 | 0·09 |
| BC239 | 0·09 |
| BC251 | 0·20 |
| BC252 | 0·18 |
| BC253 | 0·23 |
| BC257 | 0·09 |
| BC258 | 0·09 |
| BC259 | 0·13 |
| BC261 | 0·20 |
| BC262 | 0·18 |
| BC263 | 0·23 |
| BC300 | 0·42 |
| BC301 | 0·34 |
| BC302 | 0·27 |
| BC303 | 0·54 |
| BC307 | 0·10 |
| BC307A | 0·10 |
| BC308 | 0·09 |
| BC308A | 0·09 |
| BC308B | 0·09 |
| BC309 | 0·10 |
| BC309A | 0·10 |
| BC309B | 0·10 |
| BC327 | 0·24 |
| BC328 | 0·22 |
| BC337 | 0·19 |
| BC338 | 0·19 |
| BCY30 | 0·43 |
| BCY31 | 0·40 |
| BCY32 | 1·15 |
| BCY33 | 0·34 |
| BCY34 | 0·35 |
| BCY38 | 0·53 |
| BCY39 | 1·05 |
| BCY40 | 0·50 |
| BCY42 | 0·15 |
| BCY43 | 0·15 |
| BCY58 | 0·21 |
| BCY59 | 0·22 |
| BCY70 | 0·17 |
| BCY71 | 0·22 |
| BCY72 | 0·13 |
| BCY87 | 3·47 |
| BCY88 | 2·40 |
| BCY89 | 0·97 |
| BCZ10 | 0·35 |
| BCZ11 | 0·50 |
| BD115 | 0·75 |
| BD116 | 0·50 |
| BD121 | 0·75 |
| BD123 | 0·82 |
| BD124 | 0·67 |
| BD130 | 0·57 |
| BD131 | 0·40 |
| BD132 | 0·50 |
| BD135 | 0·43 |
| BD136 | 0·49 |
| BD137 | 0·55 |
| BD138 | 0·63 |
| BD139 | 0·71 |
| BD140 | 0·83 |
| BDY10 | 1·25 |
| BDY11 | 1·50 |
| BDY17 | 1·50 |

| | |
|---|---|
| BDY18 | 1·75 |
| BDY19 | 1·97 |
| BDY20 | 0·05 |
| BDY38 | 1·65 |
| BDY60 | 0·90 |
| BDY61 | 1·25 |
| BDY62 | 1·00 |
| BF115 | 0·23 |
| BF117 | 0·43 |
| BF119 | 0·58 |
| BF121 | 0·25 |
| BF123 | 0·27 |
| BF125 | 0·25 |
| BF152 | 0·20 |
| BF153 | 0·29 |
| BF154 | 0·16 |
| BF158 | 0·23 |
| BF159 | 0·27 |
| BF160 | 0·23 |
| BF161 | 0·42 |
| BF163 | 0·20 |
| BF166 | 0·35 |
| BF167 | 0·21 |
| BF173 | 0·24 |
| BF177 | 0·29 |
| BF178 | 0·35 |
| BF179 | 0·43 |
| BF180 | 0·35 |
| BF181 | 0·32 |
| BF182 | 0·40 |
| BF183 | 0·40 |
| BF184 | 0·17 |
| BF185 | 0·17 |
| BF194 | 0·14 |
| BF195 | 0·17 |
| BF196 | 0·15 |
| BF197 | 0·15 |
| BF198 | 0·15 |
| BF199 | 0·18 |
| BF200 | 0·40 |
| BF224J | 0·14 |
| BF225J | 0·19 |
| BF237 | 0·22 |
| BF238 | 0·22 |
| BF244 | 0·16 |
| BF245 | 0·33 |
| BF246 | 0·43 |
| BF247 | 0·49 |
| BF254 | 0·16 |
| BF255 | 0·17 |
| BF257 | 0·41 |
| BF258 | 0·46 |
| BF259 | 0·45 |
| BF270 | 0·25 |
| BF272 | 0·53 |
| BF273 | 0·25 |
| BF274 | 0·28 |
| BF457 | 0·53 |
| BF458 | 0·65 |
| BFS21A | 2·30 |
| BFS28 | 0·92 |
| BFS61 | 0·27 |
| BFS98 | 0·28 |
| BFW11 | 0·61 |
| BFW15 | 0·35 |
| BFX13 | 0·23 |
| BFX29 | 0·30 |
| BFX30 | 0·25 |
| BFX37 | 0·30 |
| BFX44 | 0·33 |
| BFX63 | 2·48 |
| BFX68 | 0·68 |
| BFX84 | 0·24 |
| BFX85 | 0·29 |
| BFX86 | 0·24 |
| BFX87 | 0·28 |
| BFX88 | 0·25 |
| BFX89 | 0·45 |
| BFY10 | 0·35 |
| BFY11 | 0·45 |
| BFY17 | 0·90 |
| BFY18 | 0·35 |
| BFY19 | 0·35 |
| BFY20 | 0·50 |
| BFY29 | 0·40 |
| BFY37 | 0·20 |
| BFY41 | 0·43 |
| BFY43 | 0·65 |
| BFY50 | 0·22 |
| BFY51 | 0·15 |
| BFY52 | 0·20 |
| BFY53 | 0·15 |
| BFY56 | 0·34 |
| BFY64 | 0·41 |
| BFY75 | 0·40 |
| BFY76 | 0·22 |
| BFY77 | 0·24 |
| BFY78 | 0·36 |
| BFY90 | 0·60 |
| BRY39 | 0·30 |
| BSX19 | 0·13 |
| BSX20 | 0·14 |
| BSX21 | 0·20 |
| BSX26 | 0·49 |
| BSX27 | 0·34 |
| BSX28 | 0·25 |
| BSX29 | 0·47 |
| BSX30 | 0·68 |
| BSX59 | 0·78 |
| BSX60 | 0·54 |

| | |
|---|---|
| BSX61 | 0·42 |
| BSX76 | 0·15 |
| BSX77 | 0·20 |
| BSX78 | 0·25 |
| BSW70 | 0·28 |
| BSY24 | 0·20 |
| BSY25 | 0·15 |
| BSY26 | 0·20 |
| BSY27 | 0·15 |
| BSY28 | 0·15 |
| BSY38 | 0·20 |
| BSY39 | 0·20 |
| BSY51 | 0·25 |
| BSY52 | 0·25 |
| BSY53 | 0·25 |
| BSY54 | 0·30 |
| BSY56 | 0·79 |
| BSY65 | 0·15 |
| BSY78 | 0·40 |
| BSY79 | 0·40 |
| BSY790 | 0·45 |
| BSY95A | 0·09 |
| BU104 | 1·42 |
| BU105 | 2·25 |
| CIII | 0·53 |
| D40N3 | 0·62 |
| GET111 | 0·45 |
| GET113 | 0·20 |
| GET114 | 0·20 |
| GET115 | 0·50 |
| GET119 | 0·35 |
| GET120 | 0·25 |
| GET535 | 0·20 |
| GET536 | 0·20 |
| GET538 | 0·20 |
| GET873 | 0·12 |
| GET880 | 0·30 |
| GET883 | 0·20 |
| GET887 | 0·20 |
| GET890 | 0·22 |
| GET895 | 0·25 |
| TIP29A | 0·49 |
| TIP30A | 0·58 |
| TIP31A | 0·62 |
| TIP32A | 0·74 |
| TIP33A | 1·01 |
| TIP34A | 1·51 |
| TIP35A | 2·90 |
| TIP36A | 3·70 |
| TIP41A | 0·79 |
| TIP42A | 0·90 |
| TIP2955 | 0·98 |
| TIP3055 | 0·60 |
| ME0401 | 0·18 |
| ME0402 | 0·20 |
| ME0404 | 0·13 |
| ME0411 | 0·17 |
| ME0412 | 0·18 |
| ME0413 | 0·14 |
| ME1120 | 0·25 |
| ME4001 | 0·09 |
| ME4002 | 0·11 |
| ME4003 | 0·14 |
| ME4101 | 0·10 |
| ME4102 | 0·11 |
| ME4103 | 0·10 |
| ME4104 | 0·11 |
| ME6101 | 0·14 |
| ME6102 | 0·16 |
| ME8002 | 0·17 |
| ME8003 | 0·16 |
| MJ400 | 0·78 |
| MJ420 | 0·86 |
| MJ421 | 0·88 |
| MJ430 | 0·75 |
| MJ440 | 0·71 |
| MJ480 | 0·75 |
| MJ481 | 0·85 |
| MJ490 | 0·94 |
| MJ491 | 1·10 |
| MJ802 | 14·2 |
| MJ901 | 2·65 |
| MJ1001 | 2·34 |
| MJ1800 | 1·88 |
| MJ2500 | 2·92 |
| MJ2501 | 3·25 |
| MJ2955 | 1·00 |
| MJ3000 | 2·47 |
| MJ3001 | 2·79 |
| MJ3701 | 0·9 |
| MJ4502 | 4·44 |
| MJE340 | 0·47 |
| MJE370 | 0·73 |
| MJE371 | 0·80 |
| MJE520 | 0·59 |
| MJE521 | 0·73 |
| MJE1092 | 1·93 |
| MJE1102 | 1·57 |
| MJE2801 | 1·19 |
| MJE2901 | 1·56 |
| MJE2955 | 1·65 |

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|---|---|---|---|---|---|
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| SN7401 | 20p | SN7432 | 48p | SN7473 | 40p |
| SN7402 | 20p | SN7437 | 52p | SN7474 | 40p |
| SN7407 | 56p | SN7440 | 20p | SN7475 | 45p |
| SN7410 | 20p | SN7441 | 75p | SN7476 | 44p |
| SN7411 | 22p | SN7442 | 79p | SN7481 | £1·25 |
| SN7413 | 20p | SN7443 | £1·04 | SN7483 | £1·00 |
| SN7420 | 20p | SN7444 | £1·04 | SN7484 | 95p |
| SN7421 | 22p | SN7445 | £1·85 | SN7485 | £2·50 |
| SN7422 | 48p | SN7446 | £2·00 | SN7490 | 80p |
| SN7423 | 52p | SN7447 | £1·30 | SN7491 | £1·20 |
| SN7425 | 48p | SN7450 | 20p | SN7493 | 75p |
| SN7426 | 32p | SN7451 | 20p | SN7494 | 84p |
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| SN 74119 | £1·92 | SN 74157 | £1·80 | SN 74190 | £1·95 |
| SN 74121 | £0·60 | SN 74160 | £2·60 | SN 74191 | £1·95 |
| SN 74122 | £1·35 | SN 74161 | £2·60 | SN 74192 | £1·90 |
| SN 74123 | £1·35 | SN 74164 | £2·26 | SN 74193 | £1·90 |
| SN 74141 | £0·90 | SN 74165 | £4·00 | SN 74196 | £1·60 |
| SN 74145 | £1·50 | SN 74167 | £6·25 | SN 74198 | £4·60 |
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|---|---|---|---|---|---|
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|---|---|
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| IN4517 (1·5 amp 200 pv) | 10p |
| IN5173 (1·5 amp 400 pv) | 11p |
| IN5176 (1·5 amp 600 pv) | 12p |
| IN5177 (1·5 amp 800 pv) | 15p |
| PL4007 (1·5 amp 1000 pv) | 20p |
| IN5400 (3 amp 50 pv) | 15p |
| IN5401 (3 amp 100 pv) | 17p |
| IN5402 (3 amp 200 pv) | 20p |
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| | |
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| CL1004 (10 amp 400 pv) | 47p |
| CL1005 (10 amp 600 pv) | 56p |

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| | |
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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| IN34A | 10p | BA141 | 17p | BY237 | 12½p | OA79 | 7p |
| IN914 | 7p | BA142 | 17p | BYZ10 | 35p | OA81 | 8p |
| IN916 | 7p | BA144 | 12p | BYZ11 | 32p | OA85 | 10p |
| AA119 | 7p | BA145 | 17p | BYZ12 | 30p | OA90 | 7p |
| AA129 | 15p | BA154 | 12p | OA9 | 10p | OA91 | 7p |
| BA100 | 15p | BY100 | 15p | OA10 | 20p | OA95 | 7p |
| BA102 | 25p | BY126 | 15p | OA47 | 7½p | OA200 | 7p |
| BA110 | 25p | BY127 | 17½p | OA70 | 7½p | OA202 | 10p |
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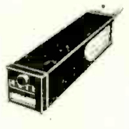

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**L.T. TRANSFORMER.** Prim. 110/240v. Sec. 0/24/40v. 1·5A. (Shrouded type). **£1·50.** P.P. 25p.
**HT/LT TRANSFORMER** Prim. 240v. (tapped) Sec. 1 500-0-500v. 150 m/a. Sec. 2. 31v. 5 amp. **£2·75** P.P. 50p.
**AUTOMATIC VOLTAGE STABILISER.** (Claude Lyons) Input: 190-260v. Output 240v. ± 15%. 12·4 K.V.A. **£60.**

**PRECISION CAPACITANCE JIGS.** Beautifully made with Moore & Wright Micrometer Gauge. Type 1. 18.5pf. to 1,220pf **£10** each Type 2, 9·5pf. to 11.5pf. **£6** each.

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6 core (6 colours) 3 screened, 14/0048. **15p.** yd. 100 yds. **£12·50.**
24 core (24 colours) **20p.** yd. 100 yds. **£17·50.**
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Minimum order 10 yds.

**TELEPHONE DIALS** (New) £1 ea.
**RELAYS** (G.P.O. '3000'). All types. Brand new from **37½p** ea. 10 up quotations only.
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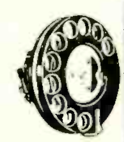

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**SIEMENS/VARLEY PLUG-IN.** Complete with transparent dust covers and bases. 2 pole c/o contacts **35p** ea; 6 make contacts **40p** ea.; 4 pole c/o contacts **50p** ea. 6-12-24-48v types in stock.
**12 VOLT H.D. RELAYS** (3 × 2 × 1 in.) with 10 amp. silver contacts 2 pole c/o **40p** ea.; 2 pole 3 way **40p.** P.P. 5p.
**24 VOLT H.D. RELAYS** (2 × 2 × ⅞ in.) 10 amp. contacts. 4 pole c/o. **40p** ea. P.P. 5p
**240v. A.C. RELAYS.** (Plug-in type). 3 change-over 10 amp. contacts. **75p** (with base). P.P. 5p.
**SUB-MINIATURE REED RELAYS** (1 in. × ¼ in.) Wt. ⅛ oz. 1 make 3/12v. **40p.** ea.
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**24 VOLT A.C. RELAYS** (Plug-in).
**3 Pole** Change-over **60p.**
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**TEKTRONIX** 526 Vectorscope **£375.**

**TEKTRONIX** 529 Waveform monitor **£320.**

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**TEKTRONIX 524D OSCILLOSCOPE** Works well but old **£60.**

**TEKTRONIX 524D OSCILLOSCOPE.** Exceptional condition. Designed for Colour TV **£120.**

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**ROHDE & SCHWARZ DIAGRAPH** Model ZDD BN 3562. Frequency 300-2400 MHZ. In Fine Condition. This difficult to shift item priced to move at **£75.**

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**ROHDE & SCHWARZ** Analyser BN 48302 **£175.**

**AMERICAN SWEEP GENERATOR** type 452. Covers from 5 to 100 MHZ. Has built in display and 101 DB Push Button RF Attenuator in one DB steps, plus Calibrated Marker Generator covering 5 to 100 MHZ continuous. American Government Contract, so quality is high. Supplied for 240V 50 HZ operation with plugs and leads. Size 13½ × 9½ × 19in. Price **£70** each. Carriage £1·50.

**AMERICAN SWEEP GENERATOR** type TRM 3 15 to 400 MHZ. **£300.**

**AMERICAN POWER UNITS STANDARD** 240V 50 HZ Input 28V 40 AMP OUTPUT. Size 22 × 16 × 9in. Supplied in original transit case **£25.**

**AMERICAN AM GENERATOR** type 497. 4 to 400 MHZ. Supplied with leads, etc., for 240V 50 HZ operation **£35.**

**POLARAD GENERATORS MODEL MSG 2,** 2150-4600 MHZ and Model MSG 34, 4200-11,000 MHZ. The pair **£130** or **£75** each.

**SPECIAL**
WM 16 Oscilloscope. Dual Timebase. 5in. tube Main frane 40 MHZ. Supplied with one single trace plug-in type 7/1. 7/5. 7/6. At give away price of **£45.** Tested, working.

**'STILL at £42·50**
Solartron CD 711S.2 Double Beam Oscilloscope DC—9 mc/s; 3 mv/cm; trigger delay; crystal calibrator; 4" flat faced tube. In good working condition. Carr. £1·50.

**SOLARTRON CD** 523 Single Beam Oscilloscope 3db at 10 MHZ; 1mV max sensitivity. DC coupled down to 1 vol. 4in. flat faced PDA tube. TB from 1 secs. per cm. to 0·1 microsecs. per cm. plus times 5 expansion **£50.**

**MARCONI TF 144H GENERATOR.** In Very Good Condition **£120.**

**MARCONI TF 195M-0/40 KHZ** Sine Wave Generator 0/40 Volts output Metered. These must go **£7·25.**

**MARCONI TF 801A AM GENERATOR** 10 to 310 MHZ **£45.**

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**MARCONI VVM TF 1041 £22·50.**

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**MARCONI VVM TF 1300.** Measures AC 50MV to 100V, 20 HZ to 300 MHZ, DC 100MV to 300V. Ohms 50 to 5 Meg Ohm. In fine condition **£17.**

**AVO TRANSISTOR AND DIODE TESTER TYPE CT 537.** In superb condition, in original crates with full instructions, circuit diagram, etc. New price £250 Plus. **OUR PRICE £40** ea. Carr. £1·25.

**BRANDENBURG EHT P/U** 0/30KV **£55.**

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**RACAL RA17 RECEIVER £230.**

**TELEQUIPMENT S51** Rack Mount Oscilloscope **£35.**

**SOLARTRON VF** 252. Millivolt meter **£20.**

**HEWLETT PACKARD SIGNAL GENERATOR MODEL 608B £70.**

**TELONIC** 100 to 250 MHZ Sweep Generator. Up to 4 watts output **£120.**

**SURFACE PROFILE MONITOR** by G. V. PLANER type SPM 10 with recorder unit. **MINT £140.**

**SLOPED CASES** size 9 × 7in. with 8in. slope, 15in. long, in Hammer Grey. Brand New boxed £1. Packing and postage 37p.

**BRAND NEW AMERICAN HIGH VOLTAGE CAPACITORS.** 0·15mfd 120kV working. **£20** each. Carriage at cost.

**MODERN TELEPHONES** type 706. Two tone grey, **£3·75** ea. The same but black, **£2·75** ea. P. & P. 25p ea.

Also **TOPAZE YELLOW £4·50** ea. P. & P. **25p.**

**STANDARD GPO DIAL TELEPHONE** (black) with internal bell, **87p** ea. P. & P. **50p.** Two for **£1·50.** P. & P. **75p.**

All telephones complete with bell and dial.

**POTENTIOMETERS**

**COLVERN** 3 watt. Brand new, 5; 10; 25; 500 ohms; 1; 2·5; 5; 10; 25; 50k all at **13p** ea.

**MORGANITE** Special Brand new, 2·5; 10; 100; 250; 500K; 1 in. sealed, **17p** ea.

**BERCO** 2½ Watt. Brand new, 5; 10; 50; 250; 500 ohms; 1; 2·5; 5; 10; 25; 50K at **15p** ea.

**STANDARD** 2 meg. log pots. Current type **15p** ea.

**INSTRUMENT** 3 in. Colvern 5 ohm **35p** ea.; 50k and 100K **50p** ea.

**BOURNS TRIMPOT POTENTIOMETERS.** 10; 20; 50; 100; 200; 500 ohms; 1; 2; 2·5; 5; 10; 25K at **35p** ea. ALL BRAND NEW.

**RELIANCE P.C.B.** mounting: 270; 470; 500 ohms; 10K at **35p** ea. ALL BRAND NEW.

**ALMA** precision resistors 100K; 400K; 497K; 998K; 1 meg—0·1% **27p** ea.; 3·25k, 5·6k, 13k-0·1% **20p** ea.

**MULLARD ELECTROLYTICS**
2200MFD 100V 10A (50°C)
**BRAND NEW BOXED**
**70p each**
**10 off — 60p each**
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**RELAYS**

**S.T.C.** Sealed 2 pole c/o 700 ohms (24V), **15p** ea. 2,500 ohm (okay 24V) **13p** ea. 6800 ohm coil **15p** each.

**POTTER & BRUMFIELD** 24V 4 pole c/o min relays. Clear Plastic. Brand New. **50p** ea. P. & P. 10p.

Varley VP4 Plastic covers 4 pole c/o 5K—**30p** ea. 15K—**33p** ea.

**CARPENTERS** polarised Single pole c/o 20 and 65 ohm coil as new **37p** each. 14 ohm coil **33p** each. 45 ohm coil **33p** each.

**TRANSFORMERS.** All standard inputs.

**STEP DOWN ISOLATING** trans. Standard 240v AC to 55-0-55V 300W, **£3** ea. P. & P. 35p.

Neptune Series. Multi 6·3 volts to give 48V at 3·5 amps etc. £3·50 incl. P. & P.

Large quantity LT, HT, EHT transformers and chokes.

**3 TYPES ALL BRAND NEW HIGH QUALITY**

(1) 3V 9 amp, 6V 9 amp, 12V 9 amp. Size 3½ × 4 × 5½in. **£2** each. Packing and postage 47p.

(2) As above but 5·4 amp. Size 3½ × 3½ × 4½in. £1·50 each. Packing and postage 37p.

(3) 3V 1·8 amp, 9V 1·8 amp, 27V 1·8 amp. Size 3 × 3½ × 4½in. £1·50 each. Packing and postage 37p.

All above 3 types also have 0-17V ½ amp and 17-0-17 ½ amp. All windings are separate.

**COLVERN TEN TURN POTS,** ex eq. 100K at **60p** each. Complete with dial **£1·50** each. P. & P. 15p.

**CAPACITOR PACK** 50 Brand new components only **50p.** P. & P. **17p.**

**POTS** 10 different values. Brand new. **50p.** P. & P. 17p.

**COMPONENT PACK** consisting of 5 pots various values, 250 resistors ¼ and ½ watt etc., many high stabs. All brand new. Fine value at **50p** per pack. P. & P. 17p.

**DELIVERED TO YOUR DOOR** 1 cwt. of Electronic Scrap chassis, boards, etc. No Rubbish. FOR ONLY **£3·50.** N. Ireland £2 extra.

**LOOSE LEAF BUNDERS.** Blue plastic cover, 4 ring. Standard size. 4 for **£1.** P. & P. 35p. 25 for **£5.** Carr. **£1.**

**P.C.B. PACK** S & D. Quantity 2 sq. ft.—no tiny pieces. **50p** plus P. & P. **20p.**

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**5 CRYSTALS** 70 to 90kHz. Our choice, **25p.** P. & P. 15p.

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**FIBRE GLASS PRINTED CIRCUIT BOARD.** Brand new. Single sided up to 2¼" wide × 15" ⅓p per sq. in. Larger pieces **1p** per sq. in. Double sided. Any size **1p** per sq. in. Postage 10p per order.

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**DECADE DIAL UP SWITCH—5 DIGIT.** Complete with escutheon. Black with white figures. Size 4in. long × 1in. high × 1½in. deep. Ex-Plessey. **£1·40** each. P. & P. 15p.

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**FIVE** moving coil meters **£2** P. & P. 37p.

**VISCONOL EHT CAPACITORS**

| | | |
|---|---|---|
| Size 1×2¼ ins. | | |
| 0·05mfd | 2·5kV | 50p ea. |
| 0·01mfd | 5kV | 40p ea. |
| 0·001mfd | 10kV | 50p ea. |
| Size 2⅛×6¼ ins. | | |
| 0·05mfd | 8kV | 50p ea. |
| Size 1⅞×5⅞ ins. | | |
| 0·01mfd | 10kV | 50p ea. |
| 0·002mfd | 15kV | 65p ea. |
| 0·0005mfd | 20kV | 60p ea. |
| 0·1mfd | 4kV | 35p ea. |

**DUBILIER** 0·1mfd 5 KV; 0·1mfd 7·5 KV; 0·25mfd 7·5 KV; 0·5mfd 5 KV all at **50p** ea. P. & P. 15p.

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**MULLARD OCP70 10p** each.

**MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH.** 2 HZ to 8 MHZ. Hook up a 9 volt battery and connect to your scope and have two traces for ONLY **£5·50.** P. & P. 25p.

**STILL AVAILABLE** our 20 MHZ version at **£9·25.** P. & P. 25p.

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In four ranges. Wien bridge oscillator thermistor stablised. Separate independent sine and square wave amplitude controls. 3V max sine, 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£7.35** each. P & P 25p. Sine Wave only **£5.35** each. P & P 25p.

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12V to 1·5 KV 2MA. Size 1½ x 2½ x 4in. Multi tapped secondary and output level control makes possible large range of voltage and current output combinations without modification. Very flexible unit at **£2·95** each. P. & P. 25p.

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5 MHZ to 150 MHZ (Useful harmonics up to 1·5 GMZ) up to 15 MHZ sweep width. Only 3 controls, preset RF level, sweep width and frequency. Ideal for 10·7 or TV IF alignment, filters, receivers. Can be used with any general purpose scope. Full instructions supplied. Connect 6·3V AC and use within minutes of receiving. All this for only **£5·75.** P. & P. 25p. Suitable miniature transformer for 240 Volt operation **£1·25.**

**Unless stated—please add £1·50 carriage to all units.**

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| Type No. | Sec. Volt Taps. | Amps. | Price | Carr. |
|---|---|---|---|---|
| 1A | 25-33-40-50 | 15 | £13·00 | 75p |
| 1B | 25-33-40-50 | 10 | £11·00 | 50p |
| 1C | 25-33-40-50 | 6 | £7·75 | 50p |
| 1D | 25-33-40-50 | 3 | £·75 | 50p |
| 2A | 4-16-24-32 | 12 | £8·75 | 50p |
| 2B | 4-16-24-32 | 8 | £7·60 | 50p |
| 2C | 4-16-24-32 | 4 | £4·75 | 40p |
| 2D | 4-16-24-32 | 2 | £3·20 | 30p |
| 3A | 24-30-36 | 10 | £8·25 | 60p |
| 3B | 24-30-36 | 5 | £6·25 | 40p |
| 3C | 24-30-36 | 2 | £3·25 | 30p |
| 4A | 12-20-24 | 20 | £10·95 | 75p |
| 4B | 12-20-24 | 10 | £6·50 | 40p |
| 4C | 12-20-24 | 5 | £4·35 | 30p |
| 5A | 3-12-18 | 20 | £9·76 | 50p |
| 5B | 3-12-18 | 10 | £6·00 | 45p |
| 5C | 3-12-18 | 5 | £4·10 | 35p |
| 6A | 48-56-60 | 2 | £4·10 | 35p |
| 6B | 48-56-60 | 1 | £3·00 | 30p |
| 7A | 6-12 | 20 | £7·50 | 50p |
| 7B | 6-12 | 10 | £4·10 | 40p |
| 7C | 6-12 | 5 | £2·75 | 30p |
| 8AI | 12-24 I | 1 | £2,10 | 25p |
| 9AI | 17-32I | 8 | £7,00 | 45p |
| 10AI | 9-15 I | 2 | £2,10 | 25p |
| 11AI | 6-3I | 15 | £4,10 | 30p |

**Note: By using the intermediate taps many other voltages can be obtained.**

Example: No. 1 .. 7-8-10-15-17-25-33-40-50v.I
No. 2 .. 4-8-12-16-20-24-32v.
No. 5 .. 3-6-9-12-15-18v.

30-25-0-25-30v. 2a. with Screen **£4·30**, carr. 35p 36-0-36v. 5a. **£9·40**, carr. 50p. As recommended for Linsley Hood Amplifiers. I

**HEAVY DUTY UNSHROUDED TYPE 9 INCH FLYING LEADS ALL PRIMARIES 240v.**

| Type No. | Sec. Volt Tap. | Amps. | Price | Carr. |
|---|---|---|---|---|
| 1 | 24-30-36 | 20 | £11·00 | 75p |
| 2 | 12-20-24 | 30 | £13·00 | 75p |
| 3 | 3-12-18 | 30 | £13·00 | 75p |
| 4 | 6-12 | 50 | £14·00 | 75p |
| 5 | 20 | 30 | £12·00 | 75p |

**DAVENSET ISOLATION TRANSFORMERS**
Pri. 10-0-200-220-240v. Sec. 240v. Centre tapped 1·2kva. Conservatively rated. Size $8\frac{1}{2}$ x 7 x $8\frac{1}{2}$ ins. Wgt. 59 lbs. Open frame type, terminal connections. Fraction of maker's price. **£17·00** carr. £1·00.

**STEP DOWN 240/110v. AUTO TRANSFORMERS FOR AMERICAN EQUIPMENT.** Fitted with 2 or 3 pin American sockets. All sizes from 80 to $2\frac{1}{2}$kva. available. Send s.a.e. for list. American sockets, plugs, adaptors also available.

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Pri. 240v. Sec. 150v. 4kva. Size 9 x $8\frac{1}{2}$ x 7 ins. Wgt. 70 lbs. **£22·50** carr. £2·00.

**RICH AND BUNDY.** Pri. 220-230-240-250v. Sec. 265-270-275v. 1400 watts. Conservatively rated. Size 8 x 8 x 7 ins. Terminal block connections. **£17·00** carr. £1·00.

**440 VOLT S.P. TRANSFORMERS**
No. 1 T.E.C. Pri. 380-400-415-440v. Sec. 33 60 amps. Size 9 x 9 x 8 ins. Terminal block connections. Conservatively rated. **£20·00** carr. £2·00. No. 2 Davenset. Pri. 415-440-525v. Sec. 220v. 2kva. Size 9 x $8\frac{1}{2}$ x 8 ins. **£25** carr. £2·00. No. 3 Davenset. Pri. 380-400-415-440v. Sec. 110v. 6 amps. Size 6 x $6\frac{1}{2}$ x $5\frac{1}{2}$ ins. **£8·50** carr. £1. No. 4 Davenset. Pri. 380-400-417-437v. Sec. tapped 110-270v. 0·15kva. Size 7 x $5\frac{1}{2}$ x 5 ins. **£6·50** carr. 75p. No. 5 Rich and Bundy. Pri. 380-400-420-440v. Sec. 240v. 40 watts. Size 4 x 4 x 4 ins. Terminal block connections. **£2·50** carr. 50p. Drake. Pri. 440v. Sec. 220-240v. 100 watts. Shrouded. **£3·25** postage 40p.

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Parmeko potted types. 5h. 500m/a. **£3·00** carr. 50p. 10h. 300m/a. **£2·00** carr. 30p. 10h. 180m/a. **£1·50** carr. 30p. 15h. 180m/a. **£2·00** carr. 50p. Swinging type 5h. ·04a. 4h. 0·25a. **£1·50** carr. 35p. 10h. 120m/a. **75p** carr. 25p. 15h. 75m/a. 10h. 75m/a. 50h. 25m/a. **50p** carr. 20p.

**PARMEKO ISOLATION TRANSFORMERS**
Pri. tapped. 100-110-200-220-230-240-250v. Sec. 115v. 13·5 amps. Conservatively rated, fully shrouded. Table top connections. Size 13 x 10 x $8\frac{1}{2}$ ins. **£32·50** carr. £2·00. Pri. tapped 200-210-220-230-240-250v. Sec. tapped 90-100-110-120v. 7·5 amps. Conservatively rated table top connections. Size 9 x 8 x 8 ins. **£22·50** carr. £1·50.

**ADVANCED COMPONENTS CONSTANT VOLTAGE TRANSFORMERS**
Input 190-260v. Output 230v. 150 watts. Type 140A **£7·00** carr. 75p. Output 28v. 8 amps open frame type **£4·50** carr. 75p. Output 4v. 3 watts **75p** carr. 25p. Output 240v. 30 watts enclosed type **£1·50** carr. 35p.

**SMITHS 12v. D.C. VEHICLE HEATER MOTORS**
3 dia. length 4 ins. Spindle $\frac{7}{16}$. Length $1\frac{1}{4}$ ins. Very powerful **£1** carr. 25p. With $6\frac{1}{2}$ in. fan **£1·25** carr. 25p. As above with twin turbo fans **£1·50** carr. 35p.

**CRESSALL TORVOLT VARIABLE TRANSFORMERS**
Input 115v. Output 0-135v. 1·25 amp. Complete with calibrated dial and control knob. Size $2\frac{1}{2}$ x $3\frac{1}{2}$ ins. dia. **£3·00** carr. 25p. Brand new.

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**AMOS 'C' L.T. TRANSFORMERS**
Primaries 220-240v. Sec. 17,5v. 6a. **£2·00** pp. 35p. Sec. 53,6v. 6a. **£2·95**pp. 40p. 18-0-18v. 5a. **£2,95** pp. 40p.

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## MULLARD ELECTROLYTIC CAPACITORS

### 071 and 072 Series

| Type No. | Working Voltage Vdc. | Capacitance µF | Max. Ripple Current at 50°C | Weight | Price |
|---|---|---|---|---|---|
| 071 14472 | 10 | 4700 | 2·5 amps | 1oz | 15p |
| 071 14682 | 10 | 6800 | 4 amps | 1oz | 17p |
| 071 15332 | 16 | 3300 | 2·4 amps | 1oz | 15p |
| 071 15472 | 16 | 4700 | 3·9 amps | 1oz | 17p |
| 071 15682 | 16 | 6800 | 5·8 amps | 1½oz | 22p |
| 071 15103 | 16 | 10000 | 7·9 amps | 2½oz | 27p |
| 071 18222 | 63 | 2200 | 5·8 amps | 3oz | 30p |
| 072 14113 | 10 | 11000 + 11000 | 10·6 amps | 3oz | 37p |
| 072 14173 | 10 | 16500 + 16500 | 13·4 amps | 4oz | 49p |
| 072 15752 | 16 | 7500 + 7500 | 10·5 amps | 3oz | 37p |
| 072 15113 | 16 | 11000 + 11000 | 13·8 amps | 4½oz | 49p |
| 071 16222 | 25 | 2200 | 2·2 amps | 1oz | 15p |
| 072 16502 | 25 | 5000 + 5000 | 9·6 amps | 3½oz | 37p |
| 072 16752 | 25 | 7500 + 7500 | 12·6 amps | 4½oz | 49p |
| 072 17342 | 40 | 3400 + 3400 | 9·1 amps | 3½oz | 37p |
| 072 17502 | 40 | 5000 + 5000 | 12·0 amps | 4½oz | 49p |
| 071 18681 | 63 | 680 | 2·1 amps | 1oz | 15p |
| 072 18172 | 63 | 1650 + 1650 | 7·8 amps | 3oz | 37p |

### 106 and 107 Series

| | | | | | |
|---|---|---|---|---|---|
| 106 14153 | 10 | 15000 | 7 amps | 4oz | 57p |
| 106 15103 | 16 | 10000 | 7 amps | 2½oz | 65p |
| 106 16223 | 25 | 22000 | 17 amps | 10oz | £1·12 |
| 106 17103 | 40 | 10000 | 12 amps | 7½oz | 94p |
| 106 18153 | 63 | 15000 | 28 amps | 18oz | £1·79 |
| 107 10222 | 100 | 2200 | 10 amps | 5½oz | 74p |

| Type No. | Voltage | Capacitance | Weight | Price |
|---|---|---|---|---|
| 102 15163 | 16 | 16000 | 8oz | 20p |
| 104 90003 | 20 | 39000 | 16oz | 30p |
| 102 16802 | 25 | 8000 | 7oz | 25p |
| 104 17562 | 40 | 5600 | 5oz | 25p |
| 104 90001 | 45 | 20000 | 16oz | 50p |

A discount of 10% may be deducted from above prices on lots of 100 of any one type,

*Please calculate the weight of your order and include appropriate postage.*

| Not over | Ordinary Parcels |
|---|---|
| 1½lb | 16p |
| 2lb | 21p |
| 4lb | 25p |
| 6lb | 29p |
| 10lb | 37p |
| 14lb | 47p |
| 18lb | 57p |
| 22lb | 67p |

## SMALL ELECTROLYTICS

| Ref. No. | Capacity | Voltage | Price |
|---|---|---|---|
| H8/1 | 1µf | 150v | 4p |
| H8/2 | 2·2µf | 25v | 4p |
| H8/2A | 3·3µf | 25v | 4p |
| H8/3 | 3µf | 50v | 4p |
| H8/3A | 4µf | 50v | 4p |
| H8/4 | 4·7µf | 25v | 4p |
| H8/4A | 5µf | 64v | 4p |
| H8/5 | 5µf | 10v | 4p |
| H8/5A | 5µf | 150v | 4p |
| H8/6A | 10µf | 10v | 4p |
| H8/7 | 10µf | 70v | 4p |
| H8/8 | 16µf | 35v | 4p |
| H8/8A | 16µf | 16v | 4p |
| H8/9 | 20µf | 6v | 2p |
| H8/9A | 20µf | 70v | 4p |
| H8/10 | 22µf | 50v | 4p |
| H8/10A | 22µf | 100v | 4p |
| H8/11 | 25µf | 12v | 4p |
| H8/11A | 24µf | 275v | 4p |
| H8/12 | 32µf | 15v | 4p |
| H8/12A | 30µf | 10v | 4p |
| H8/13A | 32µf | 50v | 4p |
| H8/14 | 40µf | 25v | 5p |
| H8/14A | 40µf | 16v | 4p |
| H8/15 | 47µf | 50v | 4p |
| H8/15A | 40µf | 35v | 4p |
| H7/1 | 50µf | 6v | 3p |
| H7/1A | 50µf | 10v | 4p |
| H7/2 | 50µf | 50v | 4p |
| H7/2A | 64µf | 2·5v | 2p |
| H7/3A | 64µf | 25v | 4p |
| H7/4 | 64µf | 15v | 4p |
| H7/4A | 64µf | 35v | 5p |
| H7/5 | 80µf | 16v | 4p |
| H7/6 | 100µf | 25v | 5p |
| H7/6A | 100µf | 15v | 4p |
| H7/7 | 100µf | 25v | 4p |
| H7/8 | 125µf | 16v | 5p |
| H7/8A | 100µf | 35v | 6p |
| H7/9 | 100µf | 63v | 6p |
| H7/9A | 125µf | 4v | 4p |
| H7/10 | 125µf | 25v | 6p |
| H7/10A | 160µf | 2·5v | 3p |
| H7/11 | 160µf | 25v | 6p |
| H7/11A | 150µf | 16v | 5p |
| H7/13A | 200µf | 25v | 8p |
| H7/14 | 220µf | 50v | 10p |
| H7/14A | 220µf | 16v | 6p |
| H7/15 | 220µf | 25v | 5p |
| H7/15A | 220µf | 35v | 10p |
| H6/1A | 250µf | 4v | 3p |
| H6/2 | | | |
| H6/3A | 320µf | 2·5v | 3p |
| H6/4 | 320µf | 10v | 4p |
| H6/4A | 330µf | 16v | 5p |
| H6/5 | 330µf | 25v | 10p |
| H6/5A | 330µf | 35v | 15p |
| H6/7 | 400µf | 15v | 5p |
| H6/8 | 470µf | 25v | 10p |
| H6/8A | 470µf | 35v | 20p |
| H6/9 | | | |
| H6/9A | 400µf | 40v | 20p |
| H6/10 | 750µf | 12v | 5p |
| H6/13A | 1000µf | 25v | 16p |
| H5/2A | 2200µf | 16v | 15p |

## NEW! NEW! NEW! NEW!

An aerosol spray providing a convenient means of producing any number of copies of a printed circuit both simply and quickly.

Method: Spray copper laminate board with light sensitive spray. Cover with transparent film upon which circuit has been drawn. Expose to light. (No need to use ultra-violet.) Spray with developer, rinse and etch in normal manner.

Light sensitive aerosol spray .. .. .. .. .. .. .. £1·00 plus
Developer and Etchant .. .. .. .. .. .. .. .. 50p postage
Copper-clad Fibre-glass Board—50p sq. ft. (max. 3' × 4')

## NEWER THAN NEW!!!

**Fibre Glass Board** pre-treated with light-sensitive lacquer enabling you to produce prototype printed circuits within five minutes.

| | |
|---|---|
| 75mm × 100mm | 33p |
| 150mm × 100mm | 66p |
| 150mm × 200mm | £1·32 |
| 250mm × 200mm | £2·20 |
| **Epoxy-Resin** | |
| 75mm × 100mm | 22p |
| 100mm × 150mm | 44p |
| 150mm × 200mm | 88p |

## VEROBOARD

| | |
|---|---|
| 2½in × 1in × 0·15in | 6p |
| 3¾in × 2½in × 0·15in | 18p |
| 3¾in × 3¾in × 0·15in | 25p |
| 5in × 2½in × 0·15in | 25p |
| 5in × 3¾in × 0·15in | 30p |
| 17in × 2½in × 0·15in | 55p |
| 17in × 3¾in × 0·15in | 79p |
| 3¾in × 2½in × 0·1in | 21p |
| 3¾in × 3¾in × 0·1in | 25p |
| 5in × 2½in × 0·1in | 25p |
| 5in × 3¾in × 0·1in | 29p |

Spot Face Cutter 38p. Pin Insert Tool 57p.
Terminal Pins (0·1 or 0·15) 36 for 22p.

## MULLARD POLYESTER CAPACITORS

500.000 in STOCK!!!

| | | | |
|---|---|---|---|
| ·001µf | ·0018µf | ·0056µf | ·015µf |
| ·0012µf | ·0022µf | | ·033µf |
| ·0015µf | ·0027µf | ·012µf | ·082µf |

20p dozen; 75p-100; £5-1,000; £40-10,000

·15µf ·18µf ·22µf ·39µf ·68µf

20p dozen; £1-100; £6·50-1,000; £50-10,000

## ERIE MONOLITHIC CERAMIC CAPACITORS

3p each; 24p dozen; £1·75 per 100

| | | |
|---|---|---|
| 10pf | 68pf | 560pf |
| 15pf | 100pf | 620pf |
| 22pf | 150pf | 680pf |
| 33pf | 220pf | 1,000pf |
| 39pf | 330pf | |
| 47pf | 470pf | |

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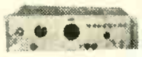
## TELEVISION SWEEP GENERATOR



by Sweep systems type 505. Frequency coverage 450-940MHz. (Channels 15-80). Markers at 465/565/660/750/830 and 900MHz. Attenuated output in eight, five db steps and fine 0-10 db. Sweep width adjustable from 1-15MHz. The instrument is completely solid-state using variactor diodes and transistors throughout. Dims: 19 x 12 x 5ins. Wt.: 20lbs. Supplied in good working order, price **£59.50** + 50p carriage.

**AERIAL CHANGE/OVER RELAYS** of current manufacture designed especially for mobile equipments, coil voltage 12v., frequency up to 250 MHz at 50 watts. Small size only, 2 in. × ⅞ in. Offered brand new, boxed. Price **£1·50,** inc. P.&P.

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**Automatic Constant current electronic battery chargers** specially designed for nickel cadmium cells. Metered and fused. Up to twelve cells can be charged up to 750mA, variable 0-750mA. Size 7x6x5ins. Brand new units. Price each **£17.**

**Smiths Ltd Weight indicators,** self powered, measures 0 to 20 cwts in 1 cwt divisions on a 4" cirscale meter indicator, 30 feet of cable and heavy duty load cell use with bell crank or actual reading is 5 cwt for F.S.D. brand new units special price **£7·50** post 50p.

**Cossor Electronic Invertors type CRA 200.** A high quality device for producing a 115v 400HZ single phase output. Incorporating the following features: Input 23-28V D.C.
* Full overload protection.
* Sine wave output.
* Remote control facilities.
* Completely Solid State (Silicon transistors).
* Built to Aircraft specifications.
* 180VA of output continuous.

May be run in series operation for 3 phase requirements. Offered brand new boxed units. Price **£17·50** Carriage 50p.

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Capacitance range 0 to 100 pf fully screened with engraved vernier subdivided into 100 equal divisions complete with vernier index and original manufacturers seal offered brand new, at only **£25** each.

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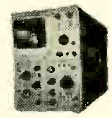

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**JERROLD 900B Sweep Generator** with SD8A sweep driver unit. V.H.F. and U.H.F. 0-1200MHz. centre frequency. 1, 10 and 100MHz markers. Built-in detector, attenuators etc. This instrument is probably the most comprehensive sweeper ever made. **P.U.R.**

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**R216 V.H.F. AM/FM Communications receivers.** Coverage 19-157MHz. Film scale dial 2 frequency crystal calibrator. Plus all other facilities. Complete with A.C. power supply connecting lead. Supplied in full working order in excellent secondhand condition.

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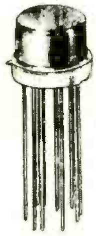
| 7405 | 16p | 14p | 12p | 7470 | 29p | 26p | 25p | 74154 | £1·80 | £1·71 | £1·60 |
| 7406 | 36p | 32p | 28p | 7472 | 29p | 26p | 25p | 74155 | £1·40 | £1·30 | £1·20 |
| 7407 | 36p | 32p | 28p | 7473 | 38p | 36p | 32p | 74156 | £1·40 | £1·30 | £1·20 |
| 7408 | 18p | 17p | 16p | 7474 | 38p | 36p | 32p | 74157 | £1·90 | £1·81 | £1·72 |
| 7409 | 18p | 17p | 16p | 7475 | 46p | 45p | 42p | 74160 | £1·80 | £1·71 | £1·60 |
| 7410 | 16p | 14p | 12p | 7476 | 40p | 39p | 38p | 74161 | £1·80 | £1·71 | £1·60 |
| 7411 | 24p | 19p | 16p | 7480 | 68p | 63p | 59p | 74162 | £4·00 | £3·76 | £3·60 |
| 7412 | 30p | 25p | 20p | 7481 | £1·20 | £1·15 | £1·09 | 74163 | £4·00 | £3·76 | £3·60 |
| 7413 | 29p | 27p | 25p | 7482 | 88p | 87p | 86p | 74164 | £2·20 | £2·16 | £2·10 |
| 7416 | 44p | 40p | 38p | 7483 | £1·11 | £1·07 | 97p | 74165 | £2·28 | £2·22 | £2·17 |
| 7417 | 44p | 40p | 38p | 7484 | £1·01 | 96p | 91p | 74166 | £3·55 | £3·28 | £3·06 |
| 7420 | 16p | 14p | 12p | 7485 | £3·00 | £2·45 | £2·10 | 74174 | £2·33 | £2·22 | £2·11 |
| 7422 | 50p | 48p | 45p | 7486 | 32p | 31p | 30p | 74175 | £1·66 | £1·55 | £1·44 |
| 7423 | 50p | 48p | 45p | 7489 | £4·49 | £4·24 | £3·98 | 74176 | £2·55 | £2·44 | £2·34 |
| 7425 | 50p | 48p | 45p | 7490 | 58p | 48p | 38p | 74177 | £2·55 | £2·44 | £2·34 |
| 7426 | 46p | 42p | 40p | 7491 | £1·00 | 95p | 90p | 74180 | £2·05 | £1·66 | £1·44 |
| 7427 | 46p | 42p | 40p | 7492 | 68p | 65p | 59p | 74181 | £5·55 | £5·10 | £4·83 |
| 7428 | 70p | 65p | 60p | 7493 | 68p | 65p | 59p | 74182 | £2·05 | £1·83 | £1·66 |
| 7430 | 16p | 14p | 12p | 7494 | 78p | 75p | 69p | 74184 | £3·55 | £3·28 | £3·06 |
| 7432 | 45p | 42p | 40p | 7495 | 78p | 75p | 69p | 74190 | £2·00 | £1·94 | £1·89 |
| 7433 | 80p | 76p | 71p | 7496 | 88p | 85p | 79p | 74191 | £1·92 | £1·97 | £1·91 |
| 7437 | 66p | 62p | 60p | 74100 | £1·65 | £1·60 | £1·56 | 74192 | £2·00 | £1·94 | £1·89 |
| 7438 | 66p | 62p | 60p | 74104 | 97p | 95p | 89p | 74193 | £2·05 | £1·66 | £1·44 |
| 7440 | 16p | 14p | 12p | 74105 | 97p | 95p | 89p | 74194 | £2·77 | £2·66 | £2·55 |
| 7441 | 68p | 65p | 60p | 74107 | 41p | 39p | 37p | 74195 | £2·05 | £1·66 | £1·44 |
| 7442 | 68p | 65p | 60p | 74110 | 56p | 54p | 51p | 74196 | £1·83 | £1·75 | £1·66 |
| 7443 | £1·30 | £1·25 | £1·19 | 74111 | £1·25 | £1·18 | £1·12 | 74197 | £1·83 | £1·75 | £1·66 |
| 7444 | £1·30 | £1·25 | £1·19 | 74116 | £1·00 | 95p | 90p | 74198 | £5·55 | £5·10 | £4·55 |
| 7445 | £1·80 | £1·76 | £1·73 | 74119 | £1·35 | £1·25 | £1·14 | 74199 | £5·55 | £5·10 | £4·55 |
| 7446 | 97p | 94p | 88p | 74121 | 40p | 38p | 35p | | | | |
| 7447 | 97p | 84p | 70p | 74122 | £1·40 | £1·30 | £1·12 | | | | |
| 7448 | £1·00 | 97p | 95p | 74123 | £2·78 | £2·67 | £2·61 | | | | |

## Linear Integrated Circuits



| | 1-49 | 50 plus | | 1-49 | 50 plus |
|---|---|---|---|---|---|
| 709c DIL | 34p | 29p | 741c 14 Pin DIL | 38p | 31p |
| 709c TO99 | 35p | 30p | 741c TO99 | 38p | 31p |
| 723c DIL | 70p | 55p | 747c DIL | 80p | 68p |
| 723c TO99 | 76p | 58p | 748c DIL | 36p | 31p |
| 741c 8 Pin DIL | 36p | 34p | 748c TO99 | 38p | 32p |

Many other types available.

## General Purpose Miniature Electrolytic Capacitors

(MULLARD & ERIE)

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 VOLT | 47µf | 6p | 10 VOLT | 4700µf | 36p | 40 VOLT | 6·8µf | 6p |
| | 100µf | 6p | | 10,000µf | 60p | | 15µf | 6p |
| | 220µf | 6p | | | | | 33µf | 6p |
| | 330µf | 6p | 16 VOLT | 15µf | 6p | | 47µf | 6p |
| | 1000µf | 12p | | 33µf | 6p | | 100µf | 6p |
| | 4700µf | 27p | | 68µf | 6p | | 150µf | 9p |
| | | | | 150µf | 7p | | 220µf | 10p |
| 6·3 VOLT | 33µf | 6p | | 220µf | 8p | | 470µf | 18p |
| | 68µf | 6p | | 680µf | 16p | | 680µf | 24p |
| | 150µf | 6p | | 1000µf | 17p | | 1000µf | 24p |
| | 470µf | 10p | | 1500µf | 26p | | 2200µf | 40p |
| | 680µf | 12p | | 2200µf | 33p | | 3300µf | 58p |
| | 1000µf | 16p | | 3300µf | 34p | | | |
| | 1500µf | 18p | | 6800µf | 57p | 63 VOLT | 1µf | 6p |
| | 2200µf | 20p | | | | | 2·2µf | 6p |
| | 3300µf | 25p | 25 VOLT | 10µf | 6p | | 4·7µf | 6p |
| | 6800µf | 36p | | 22µf | 6p | | 6·8µf | 6p |
| | | | | 47µf | 6p | | 10µf | 6p |
| 10 VOLT | 22µf | 6p | | 100µf | 7p | | 22µf | 6p |
| | 47µf | 6p | | 150µf | 7p | | 68µf | 9p |
| | 100µf | 6p | | 220µf | 9p | | 100µf | 10p |
| | 220µf | 7p | | 470µf | 12p | | 150µf | 13p |
| | 330µf | 9p | | 680µf | 18p | | 220µf | 18p |
| | 470µf | 9p | | 1000µf | 20p | | 330µf | 20p |
| | 1000µf | 12p | | 2200µf | 36p | | 470µf | 25p |
| | 1500µf | 18p | | 3300µf | 44p | | 1000µf | 40p |
| | 2200µf | 23p | | 4700µf | 62p | | 1500µf | 58p |

(Quantity discount 15%—25 plus. 20%—100 plus. 25%—250 plus.

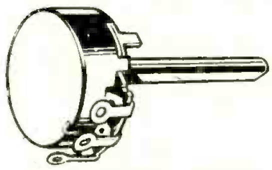
## MULLARD POLYESTER CAPACITORS C280 SERIES

250v. p.c. mounting 0·01µf, 0·015, 0·022, **3p**; 0·033, 0·047, 0·068, **3½p**; 0·1, **4p**; 0·15, 0·22, **5p**; 0·33, **6½p**; 0·47, **8½p**; 0·68, **11p**; 1·0, **13p**; 1·5, **20p**; 2·2µf, **24p**.

## MULLARD POLYESTER CAPACITORS C296 SERIES

400v.: 0·001, 0·0015, 0·0022, 0·0033, 0·0047, **2½p**; 0·0068, 0·01, 0·015, 0·022, 0·033, **3p**; 0·047, 0·068, 0·1, **4p**; 0·15, **6p**; 0·22, **7½p**; 0·33, **11p**; 0·47, **13p**.
160v.: 0·01, 0·015, 0·022, 0·033, 0·047, 0·068, **3p**; 0·1, **3½p**; 0·15, **4½p**; 0·22, **5p**; 0·33, **6p**; 0·47, **7½p** 0·68, **11p**; 1·0, **13p**.

## Volume Controls



(AB45 Series)

We are now able to offer a full range of carbon potentiometers from stock.

| | 1-49 | 50 plus |
|---|---|---|
| **Single gang less switch** | | |
| Log or Linear 1K to 2 meg. | 12p | 10p |
| **Single gang with D.P. switch** | | |
| Log or Linear 5K to 2 meg. | 24p | 20p |
| **Dual Gang less switch** | | |
| Log or Linear 5K or 2 meg. | 40p | 32p |

(Devices may be mixed to qualify for price breaks)

## Veroboard

| | ·15 matrix | ·1 matrix |
|---|---|---|
| 2½ x 3¾ | 17p | 22p |
| 2½ x 5 | 22p | 24p |
| 3¾ x 3¾ | 22p | 24p |
| 3¾ x 5 | 28p | 28p |
| 2½ x 17 | 60p | 79p |
| 3¾ x 17 | 81p | £1·05 |
| Pin insertion tool | — | 82p |
| Spot face cutter | 52p | 52p |
| Pack of 36 pins | 42p | 42p |
| | 20p | 20p |

## Presets

**Carbon skeleton presets.**

Small high quality type (Linear only). All valves 100 ohms to 10 megohms.

| | 1-49 | 50 plus |
|---|---|---|
| ·1 watt | 5p | 4p |
| ·25 watt | 6p | 5½p |

## Silicon Rectifiers

**lamp miniature**

| Type | PIV | 1-99 | 100 plus |
|---|---|---|---|
| IN4001 | 50 | 5p | 3½p |
| IN4002 | 100 | 5½p | 4p |
| IN4003 | 200 | 6p | 5p |
| IN4004 | 400 | 6½p | 5½p |
| IN4005 | 600 | 7½p | 6½p |
| IN4006 | 800 | 9p | 7½p |
| IN4007 | 1000 | 10p | 8p |

**Phone 37739 for IMMEDIATE despatch**

## Thyristors

| | | 1-49 | 50 plus |
|---|---|---|---|
| 1 AMP | 50v. | 20p | 16p |
| | 100v. | 22p | 18p |
| | 200v. | 30p | 24p |
| | 300v. | 35p | 28p |
| | 400v. | 40p | 31p |
| 3 AMP | 50v. | 44p | 40p |
| | 100v. | 50p | 45p |
| | 200v. | 60p | 54p |
| | 400v. | 66p | 58p |
| 5 AMP | 100v. | 66p | — |
| | 200v. | 80p | — |
| | 400v. | 95p | — |

## 400 mW Zener Diodes

B2Y88 Series. 3·3 volt through to 33 volt.

| 1-49 | 50-99 | 100 plus |
|---|---|---|
| 9p | 7½p | 6·8p |

## Resistors

| | | 100 plus |
|---|---|---|
| ¼ watt 5% carbon | 1p | ·7p |
| ½ watt 5% carbon | 1p | ·7p |
| 1 watt 10% carbon | 2½p | 2p |
| range 10 ohms to 4·7 megohms. | | |
| ½ watt m/o 2% | 3p | 2·4p |
| range 10 ohms to 1 megohms. | | |

## TRANSISTORS DIODES

(Quantity discount 25 plus 15%, 100 plus 20%)

| | | | | | |
|---|---|---|---|---|---|
| AC126 | 14p | BC147 | 13p | OC36 | 65p |
| AC127 | 14p | BC148 | 13p | OC44 | 10p |
| AC128 | 11p | BC149 | 13p | OC45 | 10p |
| AC176 | 12p | BC154 | 17p | OC70 | 12p |
| AC187 | 14p | BC157 | 17p | OC71 | 12p |
| AC188 | 14p | BC158 | 14p | OC72 | 14p |
| AD140 | 60p | BC159 | 14p | 2N706 | 12p |
| AD149 | 60p | BC169 | 14p | 2N2926 | 10p |
| AD161 | 32p | BC182 | 12p | 2N3055 | 49p |
| AD162 | 32p | BC183 | 12p | 2N3702 | 13p |
| AF114 | 14p | BC184 | 12p | 2N3704 | 13p |
| AF115 | 14p | BC212 | 12p | 2N3819 | 30p |
| AF116 | 14p | BC213 | 12p | 40361 | 31p |
| AF117 | 14p | BC214 | 14p | 40362 | 36p |
| AF139 | 32p | BD131 | 69p | 40636 | 76p |
| AF239 | 40p | BD132 | 69p | OA90 | 5p |
| BC107 | 10p | OC25 | 40p | OA91 | 5p |
| BC108 | 10p | OC28 | 52p | OA202 | 7p |
| BC109 | 10p | OC35 | 52p | IN4148 | 5p |

(Many other types stocked)

## Transformers

### 12-24 volt

| Secondary Volts | Amps | Volts | Amps | Part No. | Price inc. P/P. |
|---|---|---|---|---|---|
| 12 | 500mA | 24 | 250mA | MT111 | £1·20 |
| 12 | 1 | 24 | 500mA | MT213 | £1·26 |
| 12 | 2 | 24 | 1 | MT71 | £1·89 |

### 30 volt

Secondary 12, 15, 20, 24 30v.

| Amps | Part No. | Price inc. P/P. |
|---|---|---|
| 1 | MT79 | £2·02 |
| 2 | MT3 | £2·78 |
| 5 | MT51 | £5·21 |

### 50 volt

Secondary 19, 25, 33, 40, 50 volts

| Amps | Part No. | Price inc. P/P. |
|---|---|---|
| 1 | MT103 | £2·54 |
| 2 | MT104 | £3·75 |
| 4 | MT106 | £6·00 |

Many other types available.
See our Catalogue.

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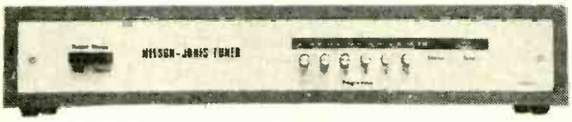
# THE NEW NELSON-JONES FM TUNER



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The tuner is available in two gain versions, and our **alignment service** is available to customers without access to a signal generator.

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**PLEASE NOTE.** Existing tuners are readily convertible and kits/parts are available for this purpose.

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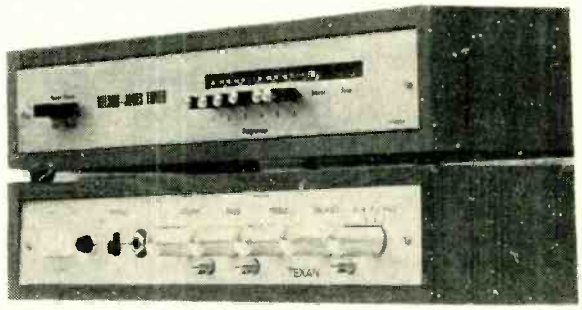
V.A.T. Please add V.A.T. at 10% to all prices for U.K. orders.



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L656/P **35p**, /S **55p**, /C3 **20p**, /R3 **20p**;
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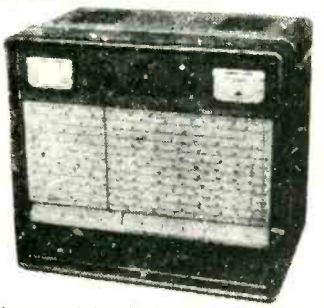
# UNIQUE OPPORTUNITIES

## GENERATORS

### MARCONI TF867 STANDARD SIGNAL GENERATOR



Carrier Frequency. Range: 15Kc/s-30Mc/s in 11 bands. Calibration Accuracy: ± 1%. Stability: After warm up the drift in a 10-minute period is, typically, less than 0·005% for carrier frequencies up to 3·2Mc/s and less than 0·01% from 3·2-2·30Mc/s. Output Voltage: 0·4µV-4V. Impedance: 75 ohms nominal for outputs from 2-4 v. 75 ohms for outputs from 4µV-2V. 13 ohms for outputs from 0·4µV-0·4V.

Accuracy: below 3Mc/s ±0·25dB of ±0·1µV. 3-10Mc/s ±0·5dB or 00·2µV. 10-30Mc/s ±1·0dB or ±0·5µV. Power Supply: 100-125V, 200-250V 40-100c/s. Dimensions: 18 in. high × 21 in. wide × 14½ in. deep. **Price £165·00**

**DOUBLE PULSE GENERATOR TYPE TF 1400/S**
10 c/s-100 Kc/s. Complete with TM 6600. Pulse adjustable between 1·5 µsec. before and up to 3,000 µsec. **PRICE £145·00**

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## FANTASTIC VALUE IN OSCILLOSCOPES

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|---|---|---|
| **TEKTRONIX** | 515 | |
| | 524AD | £125 |
| | 535A DC-30 Meg | £205 Main Frame |
| | 545 | ,, |
| | 545A | ,, £295 |

**HEWLETT PACKARD** 185B Sampling Oscilloscope DC-1000 Meg complete with 187C Dual Trace AMP has 350 microsec. Rise time (1000 MC) **£395**

**COSSOR** CDU 110 Dual Channel Transistorised DC-25 MHz at 5mV/cm. 0·2 microsec. −0·5 ± 3% 5X Magnification extends sweep speed to 40 nanosec./cm. Sweep delay 180 nanosec. **£249·50**

**COSSOR** CDU 120 Dual Channel fully transistorised 50 mV/cm to 10V DC-60 MHz. Rise time 6 nanosec. 1 mV/cm at 25 MHz. 0·1 microsec. **£349·50**

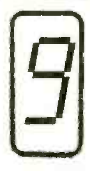
**COSSOR** CDU 150 Rugged Transistorised fully portable Dual Channel DC-35 MHz at 5mV/cm. As used by numerous government departments (c/f CT531) **£375**

**COSSOR** The very latest Cossor 4000 Dual beam. 55 MHz at 50mV/cm Trigger. SCOOP—ONE ONLY **£425**

**TEKTRONIX** 545. With delay time base **£295**

**DYNAMCO DC-60 7100**
1Y2 7100 1X2 Oscilloscope, Dual channel with sweep delay, suitable for computer maintenance and most laboratory applications 30MHz, 1mV 10ys to 5s delay.
**BRAND NEW £295**

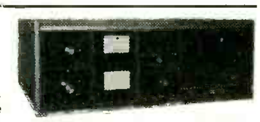
**HEWLETT PACKARD 185B**
Sampling Oscilloscope DC-IGC. Complete with 187C Dual Trace Amplifier. Has a 350 p.sec. rise time (1000MC) **£395**



**MINITRON**
K.G.M. Type 3015F 7 Segment display showing figures 0-9 plus decimal point. Character of 9mm height. In 16 DIL case.
**NEW LOW PRICE £1·40**
SN7447N BCD Decoder Driver **£1·00**

**SINE COSINE POTENTIOMETER 47K**
Precision component by Pye. Model 2002. Manufactured to rigid Ministry specification. The assembly consists of three units mounted in one frame. Each unit contains two sine and two coside potentiometer sections, the sliders being ganged together. Electrical connections, 2 end taps, slider and centre tap. Mechanical I/P: 30 r.p.m. Max. torque: 3½ oz./in. Dimensions: W. 6¼ in. H. 5 in. D. 7½ in. Wt. 7¼ lbs. Ex equipment. Good condition. Price **£5**. Carriage extra.

**INFRA-RED SPECTROPHOTOMETER**



**Beckman Type IR-102**

A single beam instrument designed primarily to analyse the effluent from a gas chromatograph, however the fast response and fast scan capabilities make it suitable for fast reaction studies involving conventional gas, liquid, or solid samples. The wave length range is 2·5 to 14·5 microns. In excellent condition. **Price £175·00**

**TRANSISTROL TEMPERATURE CONTROLLER TYPE 990**
Completely transistorised self-contained direct deflecting units for indicating and controlling temperature accurately over a wide range. Suitable where a signal can be converted into d.c. Sensitivity 10 ohms per MV. Minimum F.S.D. 8 MV. Cold junction compensation. Calibrated scale length 6·5", 0-800°C. Accuracy +/−1%. Front panel size 10" x 8½", weight 11 lbs. Mains supply 100-260 V. Control switching and thermo-couple connections all at back of case. Price **£18·50** plus **£2·00** packing and carriage.

**ASCOP DIGITAL ENCODERS**
Type 504A-8-001 **Price £20.** Type EDD8G **Price £20.**

**SYNCHROVERTER SWITCH TYPE G1280 BY ELLIOTT**
**PRICE £3.**

## POWER SUPPLIES

**POWER SUPPLIES, IBM EX-COMPUTER HIGHLY STABILISED, TRANSISTORISED LOW VOLTAGE POWER SUPPLIES.**
These modular units incorporate overload protection on both INPUT and OUTPUT. Load regulation of 1% or better. Low ripple and fast response time. Input voltage 120-130 50 Hz. Available in the following types:

| | | |
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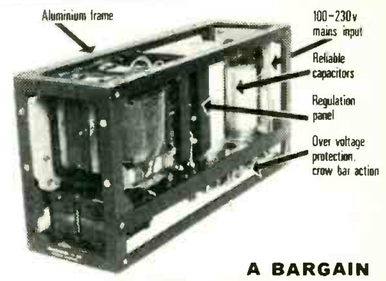
| 6 volt | 8 Amp | £21.00 |
| 6 Volt | 12 Amp | £17·00 |
| 6 Volt | 16 Amp | £20·00 |
| 12 Volt | 4 Amp | £20·00 |
| 12 Volt | 12 Amp | £22·00 |
| 12 Volt | 20 Amp | £24·00 |
| 30 Volt | 7 Amp | £19·00 |




**A BARGAIN IN NEW POWER SUPPLIES. AT LESS THAN HALF MANUFACTURERS PRICES.**
O/P Voltage 7·5V-9V. Max. load current 10 Amps. Max. ripple on full load approx. 60mV. p.p. Threshold current 10·5A. Overvolt protection. **OUR PRICE £12·50**

**EX COMPUTER HIGH GRADE FULLY STABILISED POWER SUPPLIES**
**Input 200/250V.**

| | |
|---|---|
| **ADVANCE TYPE DC 207** | 20 Volts 9 Amps.<br>10 Volts 5 Amps.<br>10 Volts 3 Amps.<br>20 Volts 2 Amps. |
| **ADVANCE TYPE DC 200** | 20 Volts 13 Amps.<br>10 Volts 5 Amps.<br>20 Volts 2·5 Amps. |
| **ADVANCE TYPE DC 202** | 35 Volts 9 Amps.<br>24 Volts 4 Amps.<br>10 Volts 8 Amps. |
| **ADVANCE TYPE DC 197** | 6 Volts 7·5 Amps.<br>6 Volts 11 Amps.<br>28 Volts 9 Amps. |
| **WESTINGHOUSE Fully Fused**<br>**Input 200/220/240/10** | 14 Volts 0·75 Amps<br>20 Volts 4 Amps.<br>25 Volts 2·5 Amps.<br>30 Volts 0·75 Amps. |
| **WESTINGHOUSE** | 6 Volts 7·5 Amps.<br>6 Volts 11 Amps.<br>28 Volts 9 Amps. |

**£18 EACH.** P. & P. £2.

**EVERSHED SAFETY OHMMETER**
for testing the continuity and resistance of circuits, consists of a hand-driven generator and a direct reading ohmmeter, Range in ohms 0-4, 0-5, 0-10, 0-100, 0-300. **£10**

**IGNITION TESTER**
Ideal for garages, this brand new instrument is used to display all ignition faults. Supplied complete with instruction manual showing photographs of displays, making use very simple. Sold complete with isolating transfer for use on 240V 50Hz supply. Display cards also available for garages and other places wishing to advertise this equipment is in use. Made by British Physical Laboratories Ltd., originally for use on the Canadian market. **Price £75**

**AVOMETERS**

| Model | Price | Model | Price |
|---|---|---|---|
| D | £14 | 40 | £16 |
| 7 | £19·50 | 47A | £16 |
| 8 | £29·50 | 48A | £16 |
| 8X | £35 | | |

NB. 47A and 48A are Admiralty versions of Model 40, the only difference being that the resistance ranges 0-1·2, 0-12 ohms, which are available on the Model 40 with the use of an external power supply are not available on the 47A and 48A. CASES AND LEADS EXTRA

**PHILIPS VALVE VOLTMETER MODEL GM6014**
Max. 300mV, 1000Hz-30MHz. **PRICE £30·00**

**ADD 10% VAT TO ALL PRICES**

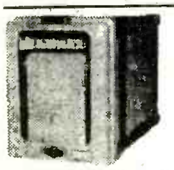
**ELECTRONIC BROKERS LIMITED**
**49/53 PANCRAS ROAD : LONDON NW1 2QB. Tel.: 01-837 7781**

# to purchase some of the World's finest calibration instruments at savings of 33⅓% AND MORE!

## PEN RECORDERS

### BRAND NEW MINIATURISED STRIP CHART RECORDER BY RUSTRAK

of America. This Recorder indicates the magnitude of applied currents or voltages by a continuous distortion-free line on pressure sensitive paper. Moving coil movement, scale calibrated 0-1 milliamp d.c. Internal resistance 100 ohms. Chart drive motor 240 V 50Hz. Chart speed 1" per hour. Complete with handbook. Price £35·00 plus £5·00 packing and carriage.



### SINGLE PEN RECORDER

by Record Electrical. 3" chart, sensitivity 1 millamp, chart speed 1" and 6" per hour. Size 8" x 11" x 6". Offered complete with pen assembly and spare chart. Listed at over £100—this month's special price due to bulk purchase ... £39·50 plus £5·00 packing and carriage.

### LEEDS & NORTHRUP STRIP CHART RECORDER

This well-known instrument is fitted with a Series 60 control unit servo amplifier 101041 BR EQ. Range: 5·571 to 18·855. Ref. junction 320F. Primary element: P1. P1. 13% RH JMC. Response time: 5 secs. for f.s.d. Chart width: 7 in. Chart speed: 1 in. per hour. Power supply: 120V 50 Hz (auto-transformer available). Dimensions: Ht. 18", width 11", depth 12¼". Weight 51 lbs. PRICE £80·00

## POTENTIOMETERS

### TEN TURN 3600° ROTATION

| Res Ohms | Linearity Per cent | Manufacturers | Model | Price |
|---|---|---|---|---|
| 100/100/100 | | Beckman | A. | £4·00 |
| 100 | 0·5 | Beckman | A.S. | £2·00 |
| 200 | 0·5 | Beckman | A. | £2·00 |
| 500 | 0·1 | Beckman | S. | £2·50 |
| 500 | | Colvern | 2501 | £2·25 |
| 500 | | Foxes | PX4 | £2·00 |
| 500 | | Colvern | 2610 | £2·50 |
| 500 | | Colvern | 26/1000/11 | £3·00 |
| 500 | 1·0 | Relcon | HEL107-10 | £2·25 |
| 1K | | Relcon | HEL0710 | £2·25 |
| 2K | 0·5 | Beckman | SA1101 | £3·00 |
| 2K | 0·25 | Beckman | 7216 | £3·00 |
| 2K | | Reliance | GPM15 | £2·00 |
| 2K | | General Controls | GPA15/4 | £2·00 |
| 5K | | Relcon | 07-10 | £2·50 |
| 5K | | Colvern | CLR2503 | £3·00 |
| 10K | 0·5 | Beckman | A. | £3·00 |
| 10K | 0·1 | Beckman X. | A. | £3·50 |
| 10K | 0·1 | Colvern | CLR26/1001 | £3·50 |
| 15K | | Colvern | CLR2402 | £3·00 |
| 18K | | Beckman | A. | £3·00 |
| 25K | 0·5 | Helipot | SAJ337 | £3·00 |
| 29K | 0·05 | Beckman | SA1244 | £4·50 |
| 30K | | Colvern | 2402 | £1·50 |
| 30K | | Beckman | SA95C | £3·00 |
| 30K | 0·1 | Beckman | A.88 | £3·50 |
| 30K | 0·5 | B.ckman | SA1692 | £3·00 |
| 30K | 0·25 | Beckman | SA1679 | £3·25 |
| 30K | 1·0 | Colvern | 2402/1 | £1·50 |
| 50K | | Reliance | 07·10 | £2·25 |
| 50K | | | 07·5 | £2·25 |
| 50K | | Colvern | 2503 | £2·25 |
| 50K | X | Foxes | PX4 | £2·25 |
| 50K | 0·5 | Beckman | A. | £3·00 |
| 50K | 0·1 | Beckman | A. | £3·50 |
| 100K/100K | | Ford | A. | £5·00 |
| 100K | 0·1 | Beckman | A. | £3·50 |
| 100K | 0·5 | Beckman | A. | £3·00 |
| 100K | | Colvern | 2501 | £2·25 |
| 100K | | Colvern | 2610 | £2·50 |
| 298K | 0·1 | Beckman | 8A3902 | £3·50 |
| 300K | 0·1 | Beckman | A. | £3·50 |

### THREE TURN 780° ROTATION

| | | | | |
|---|---|---|---|---|
| 100/100 | 0·5 | Beckman | C | £3·00 |
| 100/100 | | Beckman | Type C | £3·00 |
| 300 | | Beckman | 9303 | £2·25 |
| 1K | | Fox | PX2/H3 | £2·25 |
| 10K | 0·5 | Beckman | C.ss | £2·25 |
| 20K/20K | 0·1 | Beckman | C.S. | £3·00 |
| 10K/10K | 0·1 | Beckman | C. | £3·00 |
| 50K | 0·5 | Beckman | C.S. | £1·75 |

### FIFTEEN TURN 5400° ROTATION

| | | | | |
|---|---|---|---|---|
| 25K/25K | | Beckman B | 10 watts | £6·50 |
| 46K/46K | | Beckman B | 10 watts | £6·50 |

### TWENTY TURN 7200° ROTATION

| | | | | |
|---|---|---|---|---|
| 1 Meg. | | General Controls | PXM130 | £4·00 |
| 50K | | Reliance | | £2·00 |

### 156 TURN 56/60° ROTATION

| | | | | |
|---|---|---|---|---|
| 460 | | Kelvin Hughes | KTP0701 | £9·50 |

### FIVE TURN 1800° ROTATION

| | | | | |
|---|---|---|---|---|
| 200 | | Relcon | HEL07-05 F/11 | £2·25 |
| 500 | | Colvern | CLR2505 | £2·00 |
| U1·5K | | Colvern | CLR2605 | £2·00 |

### FIVE-AND-A-HALF TURN

| | | | | |
|---|---|---|---|---|
| 500 | | Colvern | 2405 | £2·00 |

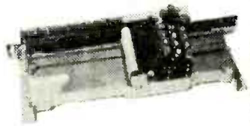
**OUR STOCKS ARE CONSTANTLY CHANGING —PLEASE LET US KNOW YOUR EXACT REQUIREMENTS**

## COMPUTER ACCESSORIES

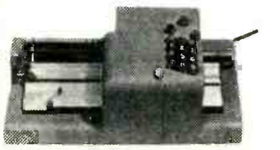
### 80 COLUMN HAND PUNCHES

Ideal for stock control, sales analysis, back-up in existing computer installations, DP training centres, schools, etc. New low cost model £59·50 plus carriage.

### DE LUXE MODEL



incorporating tabulating mechanism. £79·50 plus carriage.



### ELECTRIC HAND VERIFIER

£89·50 plus carriage.

All machines supplied with numeric keytops and dust-cover and covered by our three month guarantee. Delivery ex-stock. Optional extras alpha keytops and chip tray.

## *Special Computer Offer!*

### SAVE 75% OF LIST PRICE ON THIS DEC PDP SYSTEM

| | |
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| PDP-12C | 4K CPU and Console |
| DF32 | 32K Disk and Control |
| DWO8A | 1/0 Bus Level Converter |
| PC12 & PC05 | High Speed Reader/Punch |
| BA12 | Peripheral Expander |
| ASR33 | Teletype |
| PTO8C | Dual Channel Interface |
| KP12 | Power Fail/Restart |
| AFO1A | A/D Converter/Multiplexer |

- Fully maintained by DEC since new
- DEC maintenance available on resale
- Available in our showroom now
- Only three years old

£5000

Also available PDP 8F with ASR 33 £1150

### TELETYPE PUNCH

BRPE High-speed punch. Self-contained, consists of punch unit, base, motor unit. For use in many data communication systems. Operating speeds up to 100 characters per second. (1100 words per minute). Available for punching 5, 6, 7, or 8, level codes, into 11/16", 7/8" tape. Synchronous, parallel-wire input. £145

### WELMEC 7 & 8 HOLE ELECTRO-MECHANICAL PUNCHES & READER

Models S110 and R82C, 17 char. per sec. Rebuilt, available from stock. £45.

### ICT KEYBOARDS

In original packing—Numerical from £4·50

### ICT KEYBOARDS

In original packing—Alpha-numeric Prices from £12·50

Magnetic Tape Transporters AMPEX TM4, TM2, TM7, FR300, IBM 7330, POTTER, ICL Magnetic Drums. From £75.

### IBM PUNCH CARD EQUIPMENT FULLY GUARANTEED

| | Prices from |
|---|---|
| 024 Automatic alphanumerical keypunch | £340·00 |
| 026 Automatic alphanumeric printing keypunch | £620·00 |
| 056 Verifier features and operation same as 024, 026 | £380·00 |
| 082 Sorter 500 cards per minute are sorted | £740·00 |

Carriage extra.

### FREQUENCY CONVERTER MODEL B.40

50 KVA to 60 Hz power frequency converter. Fully overhauled.
Specification:
Prime Mover: Electric Motor
Input: 220/380V 50Hz 3ph
Output: 220V 60Hz 3ph
at 50 KVA with PF of 0·8. PRICE £450·00

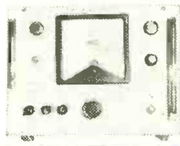
### HEWLETT PACKARD DIGITAL RECORDER MODEL 565A

Data Entry, parallel to 11 columns, Print speed 5 lines per second. PRICE £85·00.

### HEWLETT PACKARD SAMPLING OSCILLOSCOPE MODEL 185B

Including 187C. DC—100 Meg Hz. PRICE £395·00

### PYE HIGH RESISTANCE OHMMETER MODEL 10B



Range from 0·3-20,000 Megohms in 4 ranges at 500V. Used for the measurement of components or circuits having high parallel capacitance. PRICE £20·00

### MULLARD VALVE VOLTMETER MODEL E7555/2

PRICE £20·00

### COLVERN DIGITAL CODERS (Shaft Digitisers)

Digital Coders are electromechanical devices, which give a unique parallel digital code output representing the angular position of the shaft. The current handling capacity is sufficient to operate relay decodes and indicators direct without intermediate stage of amplication. 3 size magslip, 256 divisions, max. torque for reflected binary code 4·5 oz. ins. PRICE £10·00

### WIDE RANGE OSCILLATOR TYPE 400C by DAWE

1 c/s-1,000 c/s. PRICE £35·00

### FANS BY PLANNAIR

115V-3 Phase 400 c/s-11,000 rpm. Type 1PL41-234 PRICE £4·00

### R.C. OSCILLATOR TYPE G432 by FURZEHILL

Square and sinewave. 250 Kc/s. PRICE £25·00

### *SPECIAL OFFER* SPECTRUM ANALYSER HEWLETT PACKARD 8551B

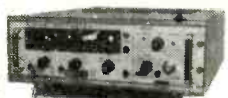
10MHz-12GHz and 851B Extension to 40GHz. With W/G Mixers and very little used Ex Calibration Lab. **£3,950·00.**

### VENNER 3334

Digital Frequency Meter 0-1MHz **£45·00.**

### VENNER 3336

Digital Counter Six Digit 0-1MHz **£55·00.**
With 15 Meg Counter extension for above **£85·00.**



### DYNAMCO 2001

Digital Voltmeter 50µV-2KV 0·05% **£175·00.**

### DYNAMCO type 2022S

Long scale D.V.M. and Ratiometer. The 2022 is a high accuracy long scale instrument operating on the potentiometric principle. It features a very high input impedance with exceptionally low current errors, an external scaling facility, seven operating modes and digital output.

| | | |
|---|---|---|
| Scale | | 39999 |
| Range | | 10µV to 2kV |
| Resolution | | 1 part in 40,000 |
| Accuracy | Long term | ±0·0025% of F.S.D. ±0·01% of reading |
| | Optimum | ±0·0025% F.S.D. ±0·0025% of reading |
| Input impedance | | >25,000 M ohm |
| C.M.R. | | 160 dB at DC, 120 dB at 50Hz } Typical |

£275·00

### MEGGLER CIRCUIT TESTING OHMMETER

For Measuring conductor resistance. By Evershed and Vignale. **£22·50.**

### BELL & HOWELL

5-12 and 18 Channel U.V. Recorder **£395.00.**
5-127 12 Channel **£350·00.**

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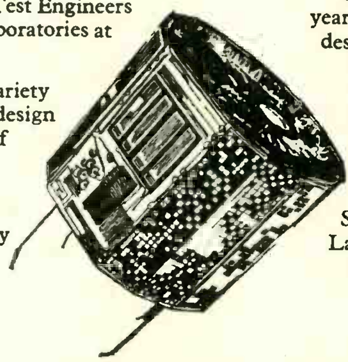
**DISPLAYED APPOINTMENTS VACANT :** £9.90 per single col. inch.
**LINE advertisements (run-on) :** 55p per line (approx. 7 words), minimum two lines.
**BOX NUMBERS :** 25p extra. (Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.)
**PHONE : Allan Petters on 01-261 8508 or 01-928 4597.**
*Classified Advertisement Rates are zero currently rated for this purpose of V.A.T.*

**Advertisements accepted up to 12 p.m. Thursday, September 6th for the October issue subject to space being available.**

# Test Engineers meet the demands of advanced satellite technology

The exacting standards of satellite work and the diversity of our military communications and underwater weapons projects provides a stimulating environment for Test Engineers at the Applied Electronics Laboratories at Portsmouth.

You will be involved in a variety of interesting work including design investigation and calibration of complex electronic circuits covering digital, analogue, VHF and microwave equipment. The work is mainly concerned with one-off prototypes, both detail and complete systems – it is closely allied to design.



We are looking for men with at least three years relevant experience. An HNC whilst desirable is not essential. Attractive salaries are offered dependent upon experience and qualifications. Relocation expenses will be met where appropriate.

Write with full details of career to date to Alan Barrett, Personnel Manager, Marconi Space and Defence Systems Limited, The Airport, Brown's Lane, Portsmouth PO3 5PH, quoting ref. LP/110/S

**Marconi Space & Defence Systems**

*A GEC-Marconi Electronics Company*

2948

# SOUND ENGINEER

ITN have a vacancy for a Sound Engineer to maintain a wide variety of sound equipment, including sound mixing desks, film and tape recording machines, film projectors and associated equipment.

Applicants should be experienced in this field, and be prepared to work either a five day week or on a shift pattern.

Contributory Staff Pension Scheme. Free Life Insurance. Four weeks holiday. Subsidised staff restaurant.

**Telephone: Personnel 01-637 3144**

2947

# ELECTRONIC ENGINEER

Recording Studio of major Record Company is looking for an Electronic Engineer with excellent knowledge of advanced transistor techniques and a degree of experience in the audio field. High qualifications essential.

**POLYDOR RECORDS STUDIO LONDON 01-499 8686 ext 51**

[2009

# FLIGHT SIMULATOR ENGINEER

## £2612 - £2666 + Shift Allowance

BEA British Airways require experienced Flight Simulator Engineers for shift duties at their Training Centre, Heston.

Qualifications required are a recognised engineering apprenticeship, or equivalent standard of training, and theoretical knowledge to HNC standard in electronic engineering.

Applicants with 3-5 years practical experience in analogue computing, digital computing and closed loop television, together with a knowledge of aircraft systems and principles of flight, are requested to write or phone for an application form to:-

**Personnel Officer (Flight Operations), BEA — British Airways, Room 1119 Queens Building, London Heathrow Airport, Hounslow, Middlesex**
**01-759 3131 ext. 2769**

2987

BEA
British Airways

UNIVERSITY OF DURHAM
INSTITUTE OF EDUCATION
Colleges of Education

# TECHNICIAN

### Closed Circuit Television Recording Unit

A Technican is needed to assist the Senior Engineer in the maintenance and operation of a well-equipped Mobile Closed Circuit Television Recording Unit serving a number of College of Education in the area, and based at Neville's Cross College, Durham. Recordings are made throughout the County. Applicants should have a basic general knowledge of television techniques and equipment. Ability to drive is essential.

Salary: Local Authority Scale T5: £1,803 to £2,100 (due for early revision), with initial placing according to age and qualifications. Conditions of service will be those applicable in a College of Education. The appointment is tenable from 1st October 1973 or as soon as possible thereafter.

Applications, including the names of two referees should be sent to the Secretary, University of Durham, Institute of Education, 48 Old Elvet, Durham, not later than Friday, 14th September, 1973.

[2975

# Receiver Technician

BBC requires a Technician in their Receiver Section at Balham. The duties include the overhaul, maintenance and installation of colour television and stereo receivers which are used for critical appraisal of technical quality and programme content. The Technician will be in direct contact with senior members of the public and the Corporation.

Candidates should have a good general education which must include a science subject and have, or be studying for, an appropriate technical qualification. They must have several years experience in television and sound receiver servicing and should be physically fit and able to work at roof height. A good personality and the ability to be tactful when working under pressure is essential. Candidates must possess a current driving licence.

Applicants who do not satisfy the requisite qualifications will be considered if they are able to demonstrate exceptionally useful experience and satisfactory knowledge at a selection board.

From 1st October appointment will normally be made in the salary range £1803-£1989 according to qualifications and experience. Technicians can progress to a roof salary of £2565. Requests for application forms to **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA quoting reference no. 73.E.4170WW and enclosing addressed foolscap envelope. Closing date for completed application forms 14 days after publication.**

[2994

BBC

# SPANISH COMMUNICATIONS EQUIPMENT MANUFACTURER

Has an immediate opening for
An experienced Design and Development Engineer for Audio Equipment, including Highly Professional Mixing Desks, Compressors, Limiters, Audio Monitoring Amplifiers, etc. Systems Experience is desirable. Salary open.

Send resumé to:
**NORTRON**
**Fernando el Católico, 63**
**Madrid 15**
**SPAIN**

[2540

# ENGINEERS

Thames Television have vacancies for Engineers at their Teddington Studios in Middlesex.

The successful applicants will assist with specific duties in our engineering complex, involving the maintenance and operation of video-tape, telecine, master control and central apparatus room equipment.

Applicants, aged between 20 and 30, should have general engineering experience, a basic knowledge of electronics and be educated to O.N.C. level or equivalent. Initiative and a keen interest in television engineering are essential personal characteristics.

The salary for this position will be in the range of £2,100 per annum to £3,000 per annum, depending upon experience. Other benefits include an excellent pension scheme, good restaurant facilities and an active sports and social club.

**Written applications should be addressed to:**
**The Staff Relations Officer, Thames Television Limited**

**THAMES**

**Teddington Lock**
**Teddington**
**Middlesex** 2902

Electronics Appointments Register

# We can get you a better job than you can get yourself.

The best jobs don't necessarily appear in the sits. vac. columns.

They are often to be found in the Electronics Appointments Register.

Our individual approach gives you a wider choice—we have lots of jobs on our specialised registers and we may well have one tailor-made for you.

The service is absolutely free to you and completely confidential.

In effect we offer you the chance to find your ideal job, all for the cost of a phone-call.

So capitalise now on your specialised knowledge.

Call 01-734 6536, or fill in the coupon and we will send you an enrolment form by return of post.

Please send me details of how to enrol on one of your Appointments Registers:

Name

Address

Post to G.A.R. 76 Dean Street London W1 01-734 6536. WW2

Graduate Appointments Registers

**CHARING CROSS HOSPITAL (FULHAM)**
**Fulham Palace Road, Hammersmith, London, W6 8RF.**

# ELECTRONICS TECHNICIAN —PATIENT MONITORING

Applications are invited for a post on the technical staff of this newly built and equipped hospital. The work involves the installation and maintenance of patient monitoring equipment on a new unit.

Applicants should have HNC or higher qualification with a minimum of three years experience, two of which should have been completed on similar work in the Health Service.

Salary on Physics Technicians grades scale £1209-£2076 plus London Weighting. 38-hour week, superannuable post. Excellent social/sport facilities including swimming pool, squash courts, bar, etc.

Applications to Mr. C. Hill, Personnel Department, telephone 01-748 2050 ext. 2992. Completed forms giving names of two referees should be returned by 3rd September, 1973.

[2914

C S L

# EXPERIENCED REPAIR AND CALIBRATION ENGINEERS

*EARN UP TO £2,700 P.A.*
*AT C S L*

Our premium rates for non-standard working hours make these earnings possible without excessive overtime.

We are one of the leading Repair and Calibration Companies with a consistently good growth record and in the process of still further expansion.

We offer stimulating and rewarding work to Engineers with a sound knowledge of circuitry and with some experience of one or more types of equipment in the range d.c. to microwaves, analogue or digital.

To find out more about job opportunities in our Company contact

The Technical Manager,

**CALIBRATION SYSTEMS LTD.**
**Blackwater Station Estate, Camberley, Surrey**
**Tel. Camberley 28121** 2932

# Electronics Engineers

## lecture on computer servicing.

International Computers Limited, Europe's leading computer company, is looking for Electronics Engineers to teach the practicalities of computer servicing. At the largest training centre of its kind in Europe, ICL will first of all ground you in computer technology and education training, and then ask you to train customer engineers to such a standard that they will be able to maintain computers at optimum operational specification.

We are looking for a thorough electronics competence and the ability to put across your own first-rate knowledge. Ideally, you will have an HNC or Forces' training in electronic engineering and at least three years' experience, preferably in digital electronics or computers.

You will be based at the training centres in either Letchworth, Herts or Feltham, Middlesex. Salaries will be good. ICL depends on talent and rewards it accordingly. You will be encouraged and expected to progress; your development could be throughout the ICL group.

For an application form, write to A. E. Turner, quoting reference WW463C at International Computers Limited, 85/91 Upper Richmond Road, Putney, London SW15 2TE.

**International Computers** **ICL**

think computers--think ICL

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## UNIVERSITY OF BATH
### School of Engineering

Applications are invited from suitably qualified persons for a post in charge of the instrumentation service (research and teaching) in the School.

Research covers a wide range of activities in the fields of Applied Mechanics, Aerodynamics, IC Engines and Turbomachinery, Structures, Production and Fluid Power Systems, supported by up to date electronic equipment currently valued at approximately £150,000 including an on-line computing facility.

The undergraduate course involves a final year project which generally requires electronic support.

Experience in the fields of computer interfacing, data acquisition systems and general electronic instrumentation would be most relevant.

The salary offered for this appointment will be at a point in a range not exceeding £3,200.

Applications giving full particulars of age, experience, qualifications and present salary together with the names of three referees should be sent to Registrar (S), The University, Bath, BA2 7AY, quoting reference 73/112.

[2979

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## BERRY'S RADIO

has vacancies for

**(a) SENIOR SALESMEN**

**(b) SENIOR ENGINEERS**

**TOP RATES OF PAY**

**5-DAY WEEK ● PERMANENCY**

**Apply: Mr. K. (405-6231)**

**319 High Holborn, London WC1**

[97

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# Storno

RADIO COMMUNICATION SYSTEMS

We have vacancies for:

**SERVICE TECHNICIANS**

based at Camberley, to work in a specialised Department dealing with miniaturised transmitter/receivers on fault diagnosis and correction. Technical experience of communications systems is an advantage.

**FIELD SERVICE ENGINEERS**

in the Greater London Area. Applicants should have experience in fault finding and testing of UHF/VHF radio equipment. Current driving licence essential, company vehicle provided.

The Company has much to offer those who are interested in the sophisticated, modern world of radiotelecommunications and who can demonstrate their ability in this field.

Please contact:

**The Personnel Officer,**
**STORNO LTD.,**
**Frimley Road, Camberley, Surrey.**
**Telephone: 0276 29131**

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## UNIVERSITY COLLEGE LONDON
### Audio Visual Unit
# TECHNICIANS

The Audio Visual Unit provides audio-visual equipment, facilities and expertise to all departments of the College, and operates a television studio equipped with Link cameras.

### Senior Audio Visual Technician (Grade 5)

He will have overall responsibility for the running of the Unit, carry out first-line servicing of all equipment, participate in the design and presentation of television programmes and be responsible for the technical aspects of this work. Salary: in the range £2,056-£2,416 including London Weighting.

### Audio Visual Technician (Grade 2B)

Duties will include operation of V.T.R's, T.V. cameras, sound mixers, audio tape recorders, film and slide projectors; routine maintenance. Salary: range £1,591-£1,846 including London Weighting.

Further details and application forms from: Personnel Officer (Technical Staff), (WW), University College London, Gower Street, WC1E 6BT.

[2963

University of Surrey Television Service

## SENIOR ENGINEER

**(Technician Grade 5 £1,881-£2,241)**

The Television Service is an integral part of the Audio Visual Aids Unit which provides services for teaching and research illustration throughout the University. The television equipment includes a most versatile mobile control room handling three Plumbicon studio cameras and five others.
The Senior Engineer will be responsible to the Chief Engineer/Operations Manager and will assist with the operation and maintenance of all CCTV equipment including IVC video-tape recorders and Philips Plumbicon cameras.
The minimum qualification is HNC in electronics or electrical engineering or an appropriate training in the BBC or a programme company. Experience in educational television is desirable.
Applications are invited immediately on forms which may be obtained from the Assistant Secretary (Personnel), University of Surrey, Guildford, Surrey. Previous applicants need not apply. Tel: Guildford 71281 Ext. 452.
Closing date: 3 September 1973. [2955

## ELECTRONICS ENGINEER

Qualified Engineer required for interesting work on a wide range of devices and systems used by and for blind people.

A sound basic knowledge of analogue and digital techniques, together with several years experience in a field of design, development and maintenance is necessary. Some experience of light electro-mechanical devices would be an advantage.

Apply: Personnel Officer, The Royal National Institute for the Blind, 224 Gt. Portland Street, London W1N 6AA.
[2953

**Devices**

## SERVICE ENGINEER
(ELECTRONICS)

Required for a Company situated in a modern new factory in Welwyn Garden City, Hertfordshire. The position involving a variety of interesting duties associated with the servicing of electronic medical equipment.

Applicants should have some previous experience in electronic servicing and full product training will be given.

A company car will be provided which may be used for private use.

Write or telephone the following:—

**Personnel Manager,**
**Devices Instruments Ltd.,**
**Hyde Way,**
**Welwyn Garden City,**
**Herts.**
**Tel: 28511 Ext. 18.** 2956

# Senior and Junior Electronic Engineers

Vacancies exist in our new Design Laboratories at Leicester for the following:

Engineers for Tape (cassette and cartridge) equipment, mainly 'in car' entertainment.

Engineers for Audio and radio equipment for the domestic market.

Electro-mechanical Design Draughtsmen.

Applicants will have several years experience of circuit design, preferably in the fields of audio equipment or electronic instrumentation and possess a degree or H.N.C. qualification or equivalent.

Salaries for the above posts are negotiable and will reflect the importance attached to the positions. Applicants are invited to write or telephone for an application form to:

**The Personnel Officer,**
**Decca Radio & Television**
**Golf Course Lane,**
**Hinckley Road,**
**Leicester.**
**Tel: 0533 872101.**

**DECCA**

# Electronics Development Engineer

IMRC is a leading company involved in the design and supply of radio communications equipment to the merchant shipping industries of the world.
We require an engineer to join our development team working on new transmitter and receiver design projects.
Applicants should have a sound knowledge of circuit design for communications equipment and ideally will have spent some time working on projects in the M.F. and H.F. bands. They should be qualified to H.N.C., or degree standard, but ability and experience will be our major concern.
Please write, with brief details of your experience and qualifications, or telephone to:—

Personnel Manager,
International Marine Radio Company Limited,
1 Peall Road, Croydon CR9 3AX.
Tel: 01-684 9771

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**ITT Marine**

# T.V. Studio Engineer

The Road Transport Industry Training Board has in operation at its Wembley Headquarters, a three camera broadcast-quality colour television studio with full telecine and video recording facilities, which includes RCA TR 50 and 1" Helical Scan systems. We now wish to appoint an experienced studio engineer to join a small team working on the production of training and educational television programmes.

The applicant should not be less than 24 years of age and have a good working knowledge of the above equipment. Salary will be negotiable depending on qualifications and experience. Three weeks holiday, contributory pension and life assurance scheme.

*Please send all relevant personal history stating how the above requirements are met, and quoting reference ZH.319, to:*

**Mrs. H. M. Brown, Personnel Manager,**
**Road Transport Industry Training Board,**
**Capitol House, Empire Way,**
**Wembley, Middlesex, HA9 ONG.**

# OPPORTUNITIES IN DESIGN

## Electronic Design Engineers

Cambridge Scientific Instruments require an engineer to join their electronics development group. His job will be the design and development of circuitry to be used in conjunction with electron optical instruments for which the Company is world famous. Due to the complex nature of these instruments, the scope of the work is varied, offering opportunities to work with many types of circuitry.

A knowledge of the application of digital and analogue integrated circuits is required and experience is desirable.

A competitive salary is offered dependent upon age and experience.

Applications should be addressed to:

**D. E. Pickett, Personnel Manager**
**Cambridge Scientific Instruments Limited,**
**Chesterton Road, Cambridge CB4 3AW.**
**Tel: 61199**

2903

# Installation Technician

## Capital Projects Department London c.£2000

The BBC Studio Capital Projects Department has a vacancy for an Installation Technician. The successful candidate will be employed on the provision of Television or Sound originating or recording equipment for both Studio and outside use.

He will assist Engineers in the preparation and requisitioning of schedules of equipment, preparation of installation information and the on site supervision, testing and commissioning of installations. An important part of his duties will consist of liaison with clerks-of-works, contractors, foremen, etc.

Applicants should have some years' experience of electronic test equipment, workshop and drawing office practice. An academic training to O.N.C. level or equivalent qualification is desirable, as is relevant experience of the manufacture, operation and maintenance of video, audio, recording or communications equipment.

The post is based in London but some travelling is required. Salary, according to experience, will be initially between £1908 and £2118, rising by annual increments to a maximum of £2805. These salaries are under review.

Requests for application forms to **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA**, quoting reference no. 73.E.4164/WW and enclosing addressed foolscap envelope. Closing date for completed application forms 14 days after publication.

BBC

2949

# SPANISH FIRM NEAR MADRID

is looking for design and development engineers with a minimum of three years of experience in the field of P.C.M. equipment to be used by the telephone industry.

Areas of interest are encoders and decoders, P.C.M. multiplexers and R.F. equipment to transmit P.C.M. data.

Salary open.

Send résumé to:

**NORTRON**
**Fernando el Católico, 63**
**Madrid 15**
**SPAIN**

2584

THE STOCK EXCHANGE
require an additional

# TELEVISION SERVICE ENGINEER

to maintain information display systems.

Applicants must possess appropriate television and radio servicing certificates and must be able to prove their ability as competent Service Engineers by a suitable trade test.

An attractive starting salary is offered. In addition, there is a non-contributory pension scheme, 3 weeks holiday in a full year and Luncheon Vouchers.

Applications giving brief details of qualifications and experience should be sent to:

**Personnel Officer,
Council of The Stock Exchange,
The Stock Exchange,
London EC2N 1HP**

[2926

UNIVERSITY OF LIVERPOOL
SCHOOL OF EDUCATION

## TECHNICIAN
## (AVA and CCTV)

Applications are invited for the above post to have overall responsibility for the AA and CCTV provision in the School.

Applicants should be qualified and experienced in the fields of electronics and Audio Visual Aids and be capable of working on their own initiative and supervising other technicians.

This is a new post with interesting possibilities of developing new forms of work in the field of Educational Technology.

Salary within a range up to £2,241 per annum according to qualifications and experience.

Further particulars and application forms may be obtained from the Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote ref. RV/WW/80410.

[2952

**HAMILTON COLLEGE OF EDUCATION**

**require a**

# TELEVISION ENGINEER
**(COLOUR UNIT)**

to join a team engaged in the operation, maintenance and development of the College service. At present the service consists of a two channel colour mobile control room with distribution facilities within the College.

Experience in video tape recorders and/or colour cameras and monitors an advantage.

Normal colour vision and driving licence essential. Annual leave will be 4 weeks.

Salary will be in the range £1530 - £2100 (N.J.C. Grade IV, V and VI) depending on qualifications and experience. (Salary scales are at present under review).

Further information and application forms may be obtained from the College Secretary with whom completed applications must be lodged not later than Friday, September 7th, 1973.

**College of Education,
Bothwell Road, Hamilton, Lanarkshire,
ML3 OBD.**

[2992

# Electronics Test Engineers

Pye Telecommunications of Cambridge and Haverhill have immediate vacancies for Production Test Engineers. The work entails checking to an exacting specification VHF/UHF radio-telephone equipment before customer delivery; applicants must therefore have experience of fault finding and testing electronic equipment, preferably communications equipment. Formal qualifications while desirable, are not as important as practical proficiency. Armed service experience of such work would be perfectly acceptable. Pye Telecommunications is the world's largest exporter of radio-telephone equipment and is engaged in a major expansion programme designed to double present turnover during the next five years. There are, therefore, excellent opportunities for promotion within the company. Pye also encourages its staff to take higher technical and professional qualifications.

These are genuine career opportunities in an expansionist company, so write or telephone without delay for an application form to:

Mrs A E Darkin at
Cambridge Works, Elizabeth Way, Cambridge CB4 1DW.
Telephone: Cambridge 51351.
or Mrs C Dawe at
Colne Valley Road, Haverhill, Suffolk.
Telephone: Haverhill 4422.

PYE Pye Telecommunications Ltd

A member of the Pye of Cambridge Group

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## WORK AS A
# RADIO TECHNICIAN
## ATTACHED TO SCOTLAND YARD

You'd be based at one of the Metropolitan Police Wireless Stations. Your job would be to maintain the portable VHF 2-way radios, tape recorders, radio transmitters and other electronic equipment which the Metropolitan Police must use to do their work efficiently.

We require a technical qualification such as the City & Guilds Intermediate (telecommunications) or equivalent.

Salary scale: £1415 to £1715 according to age from 21 to 25, to a maximum £2025 p.a. (plus a London Weighting Allowance of £175 or £90 p.a.).

Promotion to Telecommunication Technical Officer will bring you more.

For details of this worthwhile and unusual job write to: Metropolitan Police, Room 733 (RT/WW), New Scotland Yard, Broadway, London, SW1H 0BG, or telephone 01-230 3122 (24-hour service).

[2917

# Applications Engineer

## Telecommunications

An unusually interesting new appointment is available with this growing international company for a young graduate engineer, familiar with telecommunications practice generally and in particular with cables and accessories used in telephone and telegraph systems. Design experience with a cable manufacturer and/or the Post Office would be ideal.
He will be based in the Company's newly formed Communications Products laboratory at Harlow, Essex. There will be considerable European involvement, including some travel, and knowledge of a second European language would be an asset.
His prime function will be to reconcile the Company's innovations in the telecommunications field with individual national specifications in Europe, in order to provide acceptable systems to users (primarily telephone authorities). Having interpreted customer needs he will devise and apply appropriate tests and where necessary adapt or modify products to meet them.
Working largely without supervision, he will need to think clearly and to express himself fluently – a practical man who can prepare engineering drawings and fit readily into a well experienced and professional European team.
There will be a good starting salary and a full range of employee benefits. Opportunities for career development are first class in this highly diversified organisation.
Write, in confidence, with concise details to:
D. J. Stuckey (Ref: GE)
3M United Kingdom Limited,
3M House,
Wigmore Street,
London W1A 1ET.

3M

**Victoria Hospital,**
**Blackpool**

## Medical Physics Technician Grade III

Required to work on his own initiative but as a member of the Regional Physics Department and in collaboration with the Engineer's Department and Clinical Departments at Victoria Hospital, Blackpool.

This is a new post and is backed by an experienced team of Technicians together with access to the facilities of the Regional Physics Laboratory at Christie Hospital, Manchester.

Duties will include the maintenance and servicing of patient orientated electronic and electro-medical equipment to ensure correct functioning and patient safety and will initially focus on equipment in the Departments of Cardio-Thoracic Surgery and Cardiology. There is scope for the expansion of duties and, depending on the interests and capabilities of the person appointed, some development work. There is a possibility of eventful promotion to a higher grade.

Applicants should hold O.N.C., H.N.C. on a higher qualification together with a minimum of either three years experience as a Medical Physics Technician IV or V or six years relevant technical experience.

Normally the starting salary will be £1,602 rising by seven annual increments to £2,076 (Phase II increase pending).

*Application form and job description from:-*

**HOSPITAL SECRETARY,**
**VICTORIA HOSPITAL,**
**WHINNEY HEYS ROAD,**
**BLACKPOOL, FY3 8NR.**

**Closing date 24th August, 1973.** [2930

Opportunities in the
## ELECTRONICS FIELD

Men with analogue or digital qualifications/experience seeking higher paid posts in: TEST — SERVICE — DESIGN — SALES

**Phone: Roger Pearce 01-629 7306 Ref. WW**
**NEWMAN APPOINTMENTS**
**360 Oxford Street, W.1.**

2940

# RADIO OFFICERS

### DO YOU HAVE PMG I PMG II MPT
### 2 YEARS OPERATING EXPERIENCE

*POSSESSION OF ONE OF THESE QUALIFIES YOU FOR CONSIDERATION FOR A RADIO OFFICER POST WITH COMPOSITE SIGNALS ORGANISATION.*

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £2,527 pa; commencing salary according to age — 25 years and over £1807 pa. During training salary also by age, 25 and over £1350 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

***Full details from***

**Recruitment Officer, Government Communications Headquarters, Room A/1105 Priors Road, Oakley, Cheltenham, Glos GL52 5AJ, Telephone: Cheltenham 21491 Ext 2270**

**UNIVERSITY COLLEGE**
**CARDIFF**

Technician required for

## ELECTRON MUSIC STUDIO

in the Department of Physics.

Salary £1,728-£2,028 p.a.

Applications to the Registrar, University College, P.O. Box 78, Cardiff, CF1 1XL, no later than 30 September 1973. Please quote 0882.

[2942

## CHARING CROSS HOSPITAL
(FULHAM)
**Fulham Palace Rd., Hammersmith W6**

### SENIOR PHYSIOLOGICAL TECHNICIAN
**(Salary on scale £1,500-£1,953 p.a. inclusive of London Weighting)**

### PHYSIOLOGICAL TECHNICIAN
**(Salary on scale £1,236-1,689 p.a. inclusive of London Weighting)**

required for Department of Patient Monitoring currently being established. The posts will be primarily concerned with intensive care patient monitoring, but the successful applicants will also be expected to work in the Department of Cardiology, E.E.G. and Respirology.

At least 4 'O' levels required together with relevant experience, or an O.N.C. in Physiological Measurement or Equipment.

Applications with full details of age, experience, and the names and addresses of two referees, to Miss Matthews, Personnel Department, quoting ref. 810.

[2936

**London Borough of Hounslow**
**Education Department**

## TECHNICIAN

full-time, required at Heston School for the Deaf, Vicarage Farm Road, Heston, to maintain teaching aids for the deaf in nine deaf units in other schools in the Borough and one at Hillingdon. The successful candidate must hold a current driving licence. Salary on grade T.4 £1,635-£1,908. Application forms from Director of Education, 88 Lampton Road, Hounslow, Middlesex. Closing date: 14th September, 1973. Tel.: 01-570 7728, Ext. 535.

[2909

**BERKSHIRE**
**COLLEGE OF EDUCATION**

## AUDIO TECHNICIAN
**(Man or Woman)**

to work in new Resources Centre. The person appointed should have an interest in sound recording and operation of tape recorders and should be able to carry out first line service. A general knowledge of language laboratories would be an advantage but instruction will be given. Salary Technical Grade III viz. £1311-£1530 p.a.

Application forms together with further particulars obtainable from the Senior Administration Officer, Berkshire College of Education, Bulmershe Court, Woodlands Avenue, Earley, Reading, RG6 1HY. To be returned as soon as possible.

[2910

## MARCONI INSTRUMENTS LIMITED

# ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Test Technicians, Senior Test Technicians or Technician Engineers according to experience and qualifications. Our servicing and production programme, geared to our recognised export achievement, provides employment combined with prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company at Luton and St. Albans.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please write or telephone, quoting reference WW178 for application form to:

Mr. M. Leavens, Works Manager
Telephone: Luton 33866, or
Mr P Elsip, Personnel Officer
Marconi Instruments Ltd
Longacres, St. Albans, Herts
Telephone: St. Albans 59292

Member of GEC-Marconi Electronics

THE QUEEN'S AWARD TO INDUSTRY

## SERVICE REPRESENTATIVE

### FOR NUCLEONIC INSTRUMENTATION

As a result of continued growth and internal movement of personnel, Tracerlab, manufacturer of Automatic Liquid and Gamma Scintillation Spectrometers etc., need further service representatives.

We require self-motivated men who can work independently and with initiative.

Experience with digital electronics is essential, age is unlikely to exceed 35 and a background in physics and chemistry might be an advantage.

The Company offers negotiable salary, superannuation scheme, an excellent incentive bonus that encourages close co-operation in sales and a company car.

**MAKE THE CHANGE NOW**

contact: **SALES MANAGER,**
**ICN TRACERLAB,**
**2, RIVERDENE INDUSTRIAL ESTATE,**
**MOLESEY ROAD, HERSHAM, SURREY.**
**Tel: Walton on Thames 44441**

[2993

# SERVICE ENGINEER

## LKB INSTRUMENTS LTD.

requires an additional engineer to be resident in the South London, S.E. England area for field servicing of their Scientific and Technical instruments installed in Academic, Medical and Industrial Laboratories.

The successful applicant will possess a sound basic knowledge of modern electronics and will preferably have some field experience, although this is not essential.

The Company is internationally renowned for the quality of its products and offers excellent working conditions including company car, pension scheme, superannuation and profit sharing bonus scheme.

Write for application form to:

**The Service Manager,**
**LKB Instruments Limited,**
**232 Addington Road,**
**South Croydon, Surrey, CR2 8YD**

[2996

# FOREMOST IN THE UNITED KINGDOM

IN CONSTANT TOUCH WITH EVERY EMPLOYER OF EXPERIENCED ELECTRONICS ENGINEERS

Our professional placement service is specialised, confidential and completely free

Phone us at any time or write quoting WW106

ELECTRONICS APPOINTMENTS LTD
4 DRYDEN CHAMBERS,
119 OXFORD STREET,
LONDON, W1R 1PA.
TEL: 01-434 1861

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# Electronic/Technician Engineer

A responsible position is available within the Company for a person to take charge and supervise a small but expanding group of technicians engaged in the servicing and maintenance of a wide range of modern electronic equipment including portable radio, T.V., Cassette recorders, digital calculators, etc.

A working knowledge of the principles of transistor and integrated circuits pertinent to the above apparatus is required and qualifications to HNC, HND, T.Eng, Final C & G or equivalent is desirable. However, academic qualifications are not essential and proven practical ability is regarded as more important for this position where an active participation in the work is necessary.

A salary in the region of £2,500 is envisaged for this position coupled with excellent conditions and benefits of the Company situated at Audenshaw, near Manchester.

Write or telephone for applicatioin form from the Personnel Department.

**JONES SEWING MACHINE CO. LTD.**
**Shepley Street, Audenshaw, Nr. Manchester**

[2957

# Components Sales Engineer

## Car provided

Our outstanding success in the development and production of advanced test and measurement instrumentation, has enabled us to effect a degree of parallel diversification and to broach the rapid-growth area of the high-quality component market.

Consequently, we need a Sales Engineer of sufficient calibre to sell our range of RF microwave and Opto electronic components to OEM users.

He'll be covering just about one quarter of the UK, making regular personal visits to major customers and promoting both company and products through lectures, seminars, and exhibitions. He will assist the Distributor Sales force by training and joint visits, and will himself attend training programmes in Europe and the USA.

Aged between 25 and 35 with at least an HNC/HND in Electronic Engineering, he should have RF, microwave, component or semi-conductor sales/marketing experience. Previous involvement in technical sales to the TV and Radio industry would also be ideal. His experience and ability should make him a self starter capable of managing his area with minimum supervision.

We offer an excellent starting salary, a car, annual cash bonuses and other worthwhile benefits. We will also assist with removal expenses where it is necessary to re-locate.

Please ring Maureen Rowley, Personnel Administrator on Slough 35621 for an application form.

**HEWLETT hp PACKARD**

224 Bath Road, Slough, Bucks.

# SERVICE ENGINEER EXTRAORDINARY

We are seeking an unusual mixture to offer an exciting challenge, good prospects and pay. The service engineer sought should have both digital and analogue experience, mechanical aptitude and if possible knowledge of nuclear physics. He is to be based in the South East, responsible for after-sales service of liquid scintillation equipment.

Please reply in confidence to:

**MANAGING DIRECTOR**
**INTERTECHNIQUE LIMITED**
**COTTRELL HOUSE**
**53-63 WEMBLEY HILL ROAD, WEMBLEY HA9 8BE**

[2990

## ANTARCTIC EXPEDITION

# WIRELESS OPERATOR MECHANICS

**required for British stations in Antarctica.**

Applicants, preferably single and aged 22-30, should have experience of maintaining and operating SSB transmitters, receivers. Teleprinter experience desirable. Salary from £1442 per annum, all found overseas. Low income tax. Bonus for satisfactory service.

Applications to:

**British Antarctic Survey,**
**30 Gillingham Street,**
**LONDON, SW1V 1HY.**
**(01) 834 3687.**

[2905

## NEWCASTLE REGIONAL HOSPITAL BOARD

Regional Engineer's Electronics Section

Applications are invited for the following newly created posts in this increasingly important section of the Regional Engineer's Department.

### I Main Grade Electronic Engineer

This post embraces electronic design/development work connected with the hospital building programme, Technical evaluation of electro-medical equipment, and calibration/maintenance of electronic installations, and services in hospitals throughout the five Northern Counties of England.

The successful applicant will be expected to exercise initiative, whilst working as a member of a team of Electronic Engineers.

A wide experience in the field of applied electronics is essential, preferably including medical or clinical laboratory equipment, together with administrative ability.

QUALIFICATIONS: Chartered Electronic Engineer, or Degree in Electronic Engineering/Physical Electronics.

SALARY: According to age, qualifications and experience, will be in the scale:
£1866 - £3760

### II Electronic Technical Assistants

Two posts, which will be based at Newcastle upon Tyne, will involve electronic design and development work connected with the hospital buildings programme, and participation in electronic maintenance/calibration in hospitals.

Applicants must have wide experience in the practical applications of electronics.

QUALIFICATIONS: Grade I. E.R.E., or HND/HNC in Electronic/Engineering or Physical Electronics

SALARY: According to age, qualifications and experience, will be in the scale:
Technical Assistant Grade I—£2379 - £2892.

Applications, naming three referees, including details of age, present salary, education, experience etc., and indicating which post applied for should be addressed to the Secretary, Newcastle Regional Hospital Board, Benfield Road, Newcastle upon Tyne, NE6 4PY by 31st August.

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ELECTROSONIC LTD., GREENWICH

## PROJECT ENGINEER

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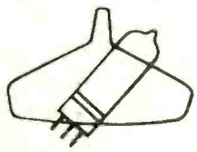

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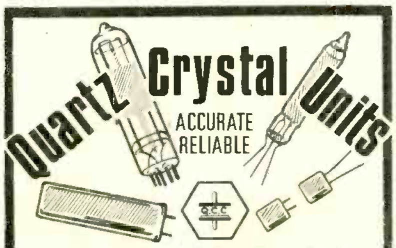

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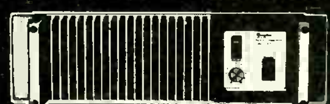

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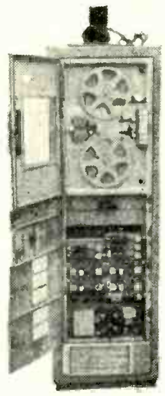

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**CLASSIFIED Continued from p. 120**

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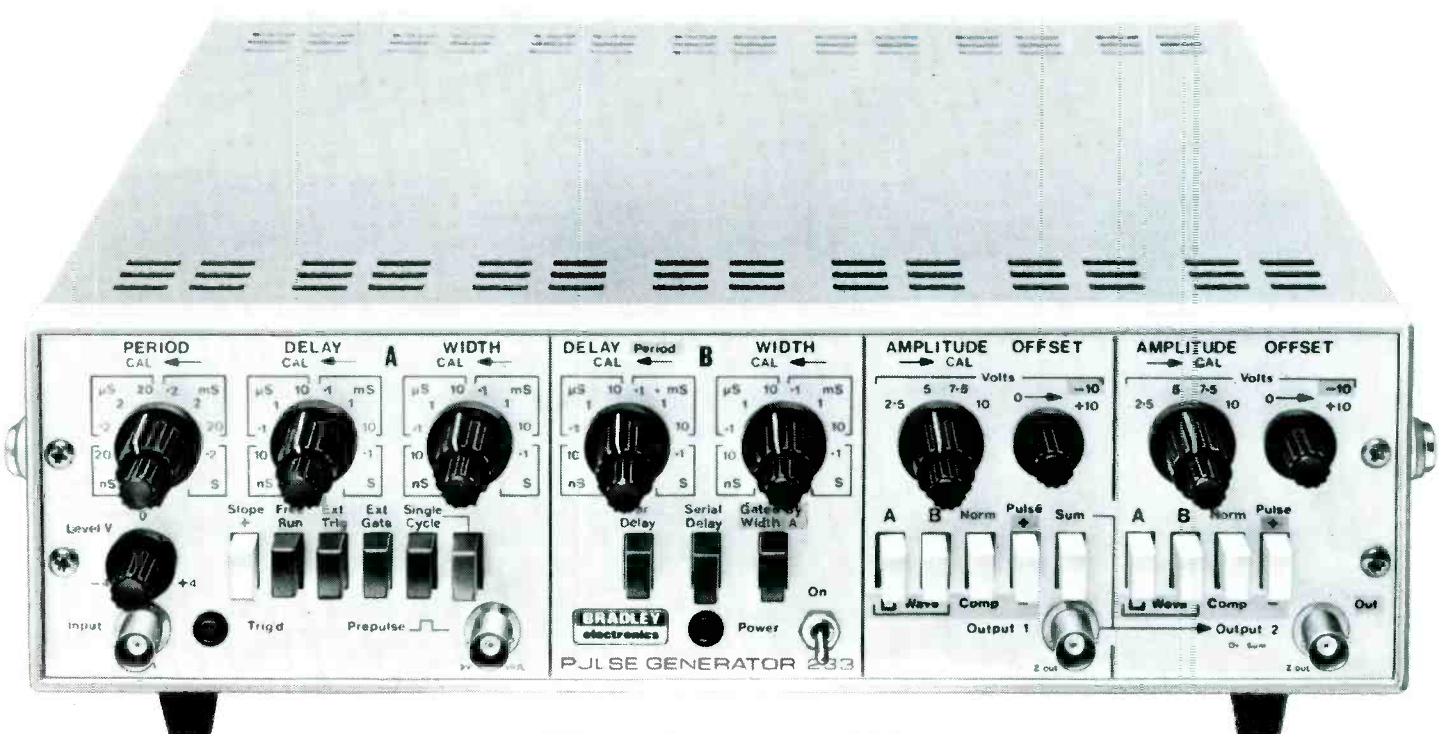


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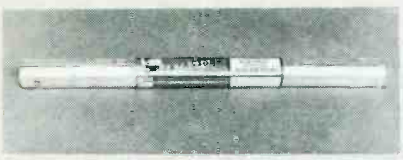

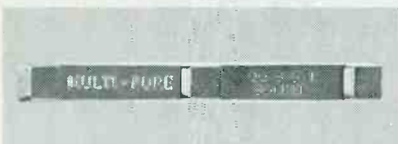


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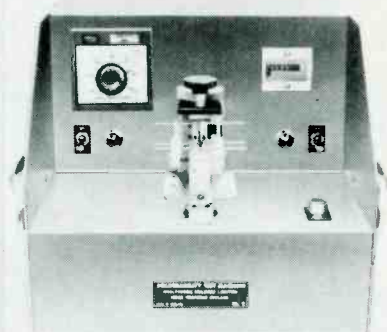

## Multicore Soldering Chemicals.

We make a complete, compatible range to assist in soldering processes. They clean, protect and preserve.

For full information on these or any other Multicore products, please write on your company's letterhead direct to:

**Multicore Solders Limited,** Maylands Avenue, Hemel Hempstead, Hertfordshire HP2 7EP.
Tel: Hemel Hempstead 3636. Telex: 82363.